Perceiving Emotions through the Kinematics of Gait and the Influence of Adaptation Aftereffects

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I hereby declare that this submission is my own work and, to the best of my knowledge, it contains no material previously published or written by another person, nor material which has been accepted for the award of any other degree or diploma at the University of Western Sydney, or any other educational institution, except where due acknowledgement is made in the thesis.

I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project’s design and conception is acknowledged.

Shaun Halovic  ………………………………
“I've been sitting far too long
At home- I've got to get along
A walk could cure most all my blues
Bare feet or in my two shoe
Bloodwood flowers in my gaze
Walkabout in a sunny daze
On a walkabout

I think I'll go on a walkabout
Find out what it's all about
Just me and my own two feet
In the heat I've got myself to meet
Use your legs to rock it wide
Take a ride to the other side”

*Walkabout* (Red Hot Chili Peppers, 1995, track 8)
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Abstract

There appears to be a common belief that at least some emotions can be perceived from the biological motion of walking. It has long been verified that specific emotions can be perceived from bodily movement in general. However, there has been little verification in the literature that this is in fact true for the specific activity of walking. This study investigated the perception of four emotions (i.e. happy, sad, anger, fear, and neutral) from the kinematics of gait style. Each of the studied emotions can be perceived solely through the kinematics of walking gait. However, the perception of these emotions are influenced by the display format (i.e. full-light, point-light, synthetically modelled), the gender of the walker and by the emotion displayed by the previously displayed walker (i.e. adaptation aftereffects). Additionally, a set of point-light walker stimuli has been created that reliably and validly display the studied emotions whilst controlling for multiple extraneous variables.

Past studies investigating emotion perception/production in gait have been plagued by methodological inadequacies (i.e. disproportionate walker gender, Montepare, Goldstein & Clausen, 1987; treadmill walking, Troje, http://www.biomotionlab.ca/Demos/BMLwalker.html; inadequate emotion priming method, Edgeworth, 2008; Michalak et al. 2009). Since there are gender differences in walking gait (Troje, 2002), we have used a relatively equal representation of male and females in our walker sample. Consequently, we have also investigated the influence of gender on the perception of emotions from walking style. Also, treadmill walking modifies the kinematics of gait which is perceivable to perceivers.
(Jokisch & Troje, 2003) therefore we used the more ecologically valid locomotive walkers. Additionally, the majority of the emotion priming methods used for the walkers has been found to be unreliable (Westermann, Spies, Stahl & Hesse, 1996) thus we used actor walkers to convey the emotions in gait and verified the success of individual walkers emotional display through inter-rater reliability.

The few studies investigating emotion perception in walking have primarily focused on how the different emotions are communicated to perceivers (i.e. specific gait movements) as opposed to how well each emotion can be relatively perceived through walking. Gibson’s (1979/1986) Ecological Theory of Visual Perception was applied to the social domain in the current research to derive hypotheses and explanations for the relative difference in the perception of different emotions. Specifically, the Alarm Hypothesis (Walk & Homan, 1984) was tested throughout this research and consequently rejected.

Actor walkers were recorded with a Vicon motion capture system and a video camera as they walked over a predetermined distance. Each of the 36 walkers (17 female) displayed each of the four emotions (i.e. happy, sad, anger and fear) at three levels of intensity (low, moderate and high). A neutral emotion was also recorded as a baseline comparison.

Full-light walker video clips of each walker were created from the video camera recordings and shown to perceivers in experiment 1. Perceivers were asked to identify the emotion displayed by each full-light walker and rate the intensity of the displayed emotion. Perceiver reaction time for identifying each emotion was
concurrently recorded. Furthermore, at the conclusion of the experiment perceiver’s were asked to describe the strategies they used, if any, to identify each emotion in the full-light walkers. Each emotion was identified above chance levels. Sad (53.3%) and fearful (56.7%) full-light walkers were identified the best and equally well as each other, followed by happiness (40.6%), then anger (32.5%) and neutral (13.2%) was identified the relative worst out of the emotions. Also, each emotion was identified better when the walker was female. Sad and fearful walkers were identified significantly slower than happy, angry and neutral walkers. However, the sad and fearful walker video clips were longer in duration due to the walkers displaying a slower walking speed across the predetermined walking space. Consequently, there was a weak but significant correlation ($\rho = .181$) between the perceiver emotion identification rates and the video clip duration. The perceived emotional intensity ratings indicated that perceivers were most sensitive to the perception of anger and fear in male walkers and sadness in female walkers. Perceivers reported identifying happiness by a bouncing gait with increased arm movement, sadness by a slow slouching gait, anger by a fast stomping gait and fear by head turning movements.

However, full-light walker displays contain much additional information that may influence emotion perception but be unrelated to the way specific emotions are perceived through the kinematics of gait (e.g. body composition, easily recognizable gender). We therefore replicated experiment 1 with the reduced point-light walker stimuli which were created from the motion capture data. Each emotion was identified above chance levels. The relative order in the perception of the specific emotions differed for each walker gender. When the point-light walker was male
happiness (31.1%) was identified the best followed by sadness (26.4%) and then by anger (19.8%), however, each of these emotions was identified equally well with fear (26.3%). When the point-light walker was female each of the four emotions (i.e. happy: 31.2%, sad: 30.2%, anger: 29.8% and fear: 29.3%) was identified equally well. Consequently, sadness and anger were identified poorer when the walker was male. Neutral emotion was identified the relative worst for both male and female walkers (9.8% and 12.1% respectively). Whilst the identification rates for the majority of the displayed emotions were lower for point-light walkers than for full-light walkers, the evidence indicates that the perception of sadness and fear is effected by display format more so than the rest of the studied emotions. The perceived emotional intensity, reaction time, video duration data and perceiver reported identification strategies largely mirrored the findings of experiment 1. We performed a kinematic analysis on the walker motion data to verify the perceiver reported gait differences for each displayed emotion. Results indicated that angry walkers displayed the fastest pace with long fast strides; happy walkers displayed long steady strides; sad walkers displayed the slowest pace with short slow strides; and fearful walkers displayed fast short strides. Both angry and happy walkers showed more arm movement than sad and fearful walkers, however, sad and fearful walkers showed less arm movement in different ways. Sad walkers moved their entire arms less whilst fearful walkers held their upper arms still and predominantly moved their lower arms consequently lessening the entire movement of their arms. 

The point-light walker stimuli nevertheless still contained some structural information of the walkers (e.g. body dimensions) and a composition of idiosyncratic gait movements which may have confused the perceivers and thus
unequally lowering the perception of the various emotions in different walkers. We therefore used a variation of Troje’s (2002) method for creating synthetically modelled point-light walkers which displayed each emotion. The synthetic walkers were normalized for all structural information and video duration. Female, male and gender ambiguous synthetic walkers were created and shown to perceivers in a replication of experiments 1 and 2. Each emotion was identified above chance levels. Happy, sad and angry walkers were identified better than fearful and neutral walkers but only when the walker was male. Happy and angry walkers were also identified better than neutral walkers in both female and ambiguous gendered walkers. All other emotions were identified equally well in male, female and gender ambiguous synthetic walkers. Furthermore, there was no difference in the perceived emotional intensity or in the perceiver identification reaction times between the different emotions or between the different genders. Each of the studied emotions was therefore displayed equivalently solely through the kinematics of gait. Furthermore, the created synthetic point-light walker stimuli can be used in future research to investigate emotion perception in walking style whilst controlling for many of the variables that have plagued past research.

As such, we used our improved stimuli to further explore emotional gait perception by investigating a previously established influence on visual perception: adaptation aftereffects. Past research has found adaptation aftereffects for the perception of emotions in facial expression and for gender in gait but not for emotion perception in gait. Therefore, a second set of three experiments investigated whether adaptation aftereffects influence the perception of emotions in walking style. Auxiliary experiment 4a verified that a neutral walker did not create
adaptation aftereffects in the subsequent perception of emotions displayed by walkers thereby allowing the neutral walker to act as a statistical comparison.

Experiment 4b investigated the existence and nature of adaptation aftereffects for emotion perception in gait. Results indicated that after adapting to an angry walker the identification of anger was inhibited but the identification of fear was facilitated. Also, after adapting to a fearful walker, fear was identified slower but anger was identified faster. Likewise, happy walkers were identified slower after adapting to a happy walker but faster after adapting to a sad walker. All these results were found to be low level phenomenon suggesting that theoretically opposite emotions (i.e. happy/sad, angry/fear) are communicated through oppositional motion. Experiment 5 contrasted the neural fatigue theory against the adaptation theory of adaptation aftereffects by varying the duration of non-stimulation between the adapting walker and the target walker. Results indicate clear support for the neural fatigue theory of adaptation aftereffects.
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Chapter 1

General Introduction

When I was a child I was fanatical about sport, particularly cricket. From the beginning I wanted to be a great bowler. I lacked the strength and power to be an efficient pace bowler, so instead I developed into a spin bowler. A spinner, being a slower bowler, gives the batsman more time to judge how to react and thus must use guile and cunning to deceive the batsman through spinning the ball.

Whenever I took a wicket, a new batsman would walk out to the middle of the oval. I would know next to nothing about this new batsman. Nevertheless I did not want to wait for a couple of overs to figure out this particular batsman’s weaknesses. I would want to get them out on the very next ball. So I would watch them walk out to the pitch, attempting to glean some insight into this new opponent. I would attempt to predict what style of batsman they were solely from their movement. Did they play a technically correct game? Were they going to attack my bowling straight away? Were they weak off the front or the back foot? By knowing my opponents strengths and weaknesses, I could exploit them to my own (and my team’s) benefit. Over the years I developed this skill until it became reasonably accurate, and transferred this skill into my other sports.

What I was attempting to do in each of my sporting environments was perceive character traits and psychological states from their biological motion. Whilst I was only training myself to use this skill in sport, this ability is found in many other fields of human activity (e.g. social courtship, victimisation). It is often stated that
we can perceive a large number of traits and psychological states from biological motion (victim potential, Gunns, Johnston, & Hudson, 2002; Johnston, Hudson, Richardson, Gunns, & Garner, 2004; Winkel, & McCormack, 1997; social status, Schmitt & Atzwanger, 1995; walker gender, Troje, 2002; and person identification, Westhoff, 2005). It is known that specific emotions can be perceived through biological motion (Dittrich, Trosclair, Lea, & Morgon, 1996; Pollick, Paterson, Bruderlin, & Sanford, 2001; Walk & Homan, 1984) and from walking in particular (Lemke, Wendorff, Mieth, Buhl, & Linnemann, 2000; Montepare, Goldstein, & Clausen, 1987). However, it is not yet known exactly how the emotion of a walker is perceived by an onlooker through the biological motion of walking. Therefore in the research reported here, we will investigate if emotions can be perceived from walking style. Subsequently, we will investigate which gait cues are being used by perceivers to identify each emotion to gain an understanding of how emotions are perceived from gait. Additionally, we will investigate the perceptual relationship between the studied emotions by investigating the influence of adaptation aftereffects on emotional gait perception.

To investigate these main research aims, we will conduct two series of experiments. The first series of three experiments will primarily investigate if emotions can be perceived through gait and whether this perception is influenced by walker gender. First, perceivers will attempt to perceive emotions from the ecologically valid full-light video displays of emotional gait (Chapter 7: Experiment 1). The stimulus information will then be systematically reduced in the two subsequent experiments to point-light walkers (Chapter 8: Experiment 2) and synthetically modelled point-light walkers (Chapter 9: Experiment 3) respectively.
The synthetically modelled point-light walkers will display the studied emotions solely through gait kinematics thus answering whether emotions can be perceived from gait kinematics alone. Furthermore, the point-light walker stimuli will be kinematically analysed to determine how each of the studied emotions is displayed through gait.

The second series of experiments will explore the relative perceptual relationship between different perceived emotions displayed through gait (Rutherford, Chattha & Krysko, 2008) by investigating an important methodological confound: adaptation aftereffects. The first of these experiments will directly investigate whether adaptation aftereffects influence emotional gait perception and in what way (Chapter 10: Experiment 4a and Chapter 11: Experiment 4b). The last experiment will contrast two competing theories of adaptation aftereffects against each other (Chapter 12: Experiment 5).

This thesis will conclude with a review of these experiments results and a discussion of the importance of this research to current scientific literature and to the wider community (Chapter 13). However first, we will review the theories of visual perception and their importance for research on human biological motion (Chapter 2). Third, we will review the literature concerning the expression and perception of emotions from human biological motion (Chapter 3). Fourth, we will review the methodological arguments pertaining to walking gait research and the literature concerning how emotions may be perceived from walking style (Chapter 4). We will follow these literature review chapters with the rationale for the present research (Chapter 5) and a description of our stimulus construction (Chapter 6).
Chapter 2

Theories of Visual Perception of Human Biological Motion

2.1 Perception of Human Biological Motion

Human perception of biological motion has attracted much research attention over the last 30 years and, with advancements in technology, new insights into perception of biological motion have arisen. *Biological motion* is defined as the “visual perception of a biological entity engaged in a recognizable activity [or] the visual system’s ability to recover information about another’s motion from sparse input” (Pelphrey & Morris, 2006, p136). Gunnar Johansson (1973), who was the first to coin the term biological motion, showed that biological motion could be perceived when the visual stimulus is stripped of all but kinematic information. *Kinematics* is defined as the spatial and temporal components of motion (e.g. velocity, acceleration) without mention of the forces that produce those movements (e.g. muscle strength, physiological energy systems). Johansson (1973) attached reflective markers to the joints of walkers as he filmed them. He then reduced the brightness of the display of the filmed walkers so that perceivers could only see dots of light. When the filmed stimulus was held static no recognition of the human figure could be seen. However, when the film was played and the lights moved, perceivers could identify that it was a human figure walking. This type of display has been called *point-light display*. It is claimed that point-light display reduces the visual information to only kinematic information (Johansson, 1973) and thus is intimately linked to the study of biological motion, as per the second previously mentioned definition of biological motion (Pelphrey & Morris, 2006). Reducing visual information to kinematics is preferable for the study of biological motion.
because it limits the influence of possibly confounding variables (e.g. age, gender, ethnicity). With the advancement of technology, motion capture equipment (e.g. Vicon) is now often used (Troje, 2002; Westhoff, 2005) over traditional point-light recording methods (Cutting & Kozlowski, 1977; Johansson, 1973). Motion capture equipment uses a computer to record the changing position of markers in three-dimensional space (discussed further in Section 6.2.2.). Thus, in addition to creating point-light displays, motion capture equipment can record and measure movement kinematics.

Johansson (1973) argued that point-light displays reduce the stimulus to only kinematic information. While point-light displays strip the visual information of cues that could influence the judgements made from full video displays (e.g. ethnicity), the spatio-temporal relationship of the various points can provide the information required for a perceiver to infer the structure of the point-light figure (e.g. size, build, height). Cutting, Proffitt and Kozlowski (1978) showed that the elliptical movement relationship of the point-lights on both the shoulder and hip provided sufficient information to correctly identify the sex of the walker. Cutting et al. wrapped marker tape on both sides of the walker’s body and the recorded point-light walker stimuli were presented to viewers from a sagittal perspective. Nevertheless, the perceivers were able to view the point-light movement of both limbs of each walker from the one side-on perspective. However, this perspective limits the ability of an observer to infer structural information from kinematic information because the width of the body can not be seen. Nevertheless structural information that allows perception of the walker’s sex can be inferred. Men who, relative to women, typically have larger shoulders than hips produced more
movement in the shoulders than the hips. In contrast, women who typically have hips and shoulders of similar width produced nearly identical movements of both body parts. Further point-light research specific to walking and emotions will be discussed in Section 4.3.

However, a theoretical understanding of visual perception is needed to explain the human ability to perceive biological attributes from another’s motion. Thus, in the next section we will review some competing theories of visual perception and argue for the preference of Gibson’s (1979/1986) ecological theory of visual perception as the most appropriate theory to use in our research on emotion perception from walking style. It should be noted that we will not be testing these reviewed theories against each other in this research. The ecological theory of visual perception (Gibson, 1979/1986) will be used to explain the pattern of results arising from each experiment conducted throughout this thesis research. Furthermore, many of the hypotheses tested throughout this research are derived from the predictions of ecological theory (Gibson, 1979/1986) but will be raised and discussed later in more relevant sections to the particular hypothesis.

2.2. Theories of Visual Perception

2.2.1. Ecological theory of visual perception.

Gibson’s (1979/1986) ecological theory of visual perception provides one effective theoretical framework for investigating the perception of biological motion. Gibson intended the theory to explain how we navigate and interact with our environment through visual means. The theory rests on two assumptions. The first (and most important) assumption is that ‘perception is for doing’ (Gibson,
1979/1986). This means the purpose of perception is so we can effectively interact with our environment. Thus there is an implicit assumption that perception and action are intimately linked. Neurological evidence supports this assumption. Brain areas that are activated during activity are also activated when perceiving or imagining the same activity (Calvo-Merino, Glaser, Grezes, Passingham, & Haggard, 2005; Decety & Chaminade, 2003; Vingerhoets, de Lange, Vandemaele, Deblaere, & Achten, 2002; see Section 3.3.3. for further discussion of the neurological evidence).

Another assumption of Gibson’s (1979/1986) theory is that perception occurs in real time (Greeno, 1994), also known as direct perception. By real time it is meant that an individual perceives something as it unfolds, as opposed to the traditional cognitive theories where a time period of cognitive processing is required for perception to occur. This assumption of direct perception is particularly relevant to the perception of biological motion: both biological motion and inanimate motion are dynamic in nature, but they are differentiated from each other by the cause, origin or source of the motion. Inanimate motion is the consequence of physical forces on an inanimate object (e.g. a boulder rolling down a mountain), whilst in biological motion the individual creates the forces required for the motion (e.g. a person walking). Thus the individual is also capable of changing his or her behaviour as reaction to movements of the ‘observer’ (Waugh, 2004). Therefore the mutually influential relationship between perceiver and perceived provides a more compelling argument that the perception of an individual moving is conducted in real time. If time is spent processing what has just been perceived, subsequent movements made by the individual might be missed. Missing the perception of an
individual’s movements disallows the perceiver to consequently adjust their behaviour and thus could be potentially dangerous. We often need to react to another organism’s movements quickly (without spending time on processing the movement information), especially if their movements are dangerous (e.g. a snake strike). Reactive movements need to be continuously updated with perceptual information for an organism to judge whether the reactions are sufficient to successfully avoid the attack. Continuously updating perceptual information implies that perception is conducted in real time. Ecological psychologists call the process of direct perception in action circular causality (Shaw & Wagman, 2001) which holds that “agents perceive how to reach a goal and then, the acting updates the next goal-specific perceiving, which then updates the next goal-relevant acting, and so on, until the goal is reached or the effort is aborted” (p905). Information processing, on the other hand, could have serious consequences for our survival when considering the circumstance of being attacked due to the temporal incongruence between the mind and the environment. The same is true for when a perceiver perceives the emotional state of another individual from non-verbal communicative signals (e.g. walking). Emotion is a response to a variety of situations (real or imagined) that are relevant to the individual’s personal goals (Rottenberg, Ray & Gross, 2007) and the emotional state of another individual can change very quickly due to environmental changes. Felt emotion is therefore dynamic due to its continually responsive nature. The dynamic nature of emotion therefore requires two people who are engaged in social interaction with each other to perceive and respond just as quickly to each others emotional state (Blake & Shiffrar, 2006; Waugh, 2004). The perception of emotion in others therefore must be done in real time (i.e. circular causality). The ecological theory that perception occurs in real time is preferable to traditional cognitive
processing approaches for underpinning an investigation into the perception of emotion in walking.

Gibson’s (1979/1986) ecological theory proposes that visual perception is derived from the combination of four factors: adaptability, attunement, affordances and events. *Adaptability* states that our perceptual systems have evolved over time to enhance our chances of survival. *Attunement* states that our perceptual systems are educated by experience to become more efficient at perceiving important stimuli in the environment. An example of attunement would be the expert boxer who needs to pick up minimal movement information to ascertain what type of punch is being thrown at them. A novice boxer needs to pick up significantly more information to perceive what punch is being thrown and thus requires longer time to react and is more likely to be hit. *Affordances* state that everything that is perceived provides the opportunity to interact with it in some way. Another person can afford interaction, fruit may afford eating etc. Affordances are specific to the individual and the context. When two people perceive another person they may have completely different affordances (e.g. opportunity for love compared with the opportunity for assault). Affordances make explicit the relationship between the perceiver and the perceived. Perception can not exist without this relationship. *Events* state that certain information underlying an object can present itself only under movement. A point-light display is a good example. When a point-light display of a walking figure is shown in a static form it appears as just random dots. But when the same stimulus is displayed dynamically a walking figure is perceived (Johansson, 1973). The dynamic nature of event perception is particularly pertinent when investigating
human movement (e.g. walking) and the psychological states that are displayed through human movement (e.g. emotion).

Gibson (1979/1986) intended his theory on visual perception as a way of explaining our perception of the environment. Our social environment was not the original focus of the theory. McArthur and Baron (1983) extended Gibson’s theory so that it could be applied to the social domain. McArthur and Baron called their revised theory the ‘ecological theory of social perception’. The authors argued that Gibson’s ecological theory could be effectively applied to the social domain because of the characteristics of social interaction. Both perception and action must exist for social interaction to occur. The intimate link between perception and action is consistent with Gibson’s first assumption that perception is for action. Social interaction is also dynamic in nature (Blake & Shiffrar, 2006; Waugh, 2004) and occurs in real time. This characteristic is consistent with Gibson’s assumption that perception occurs in real time.

Social interaction occurs on many levels, including interaction through nonverbal means (e.g. facial expressions, hand gestures, walking style). Since ‘perception is for doing’ (Gibson, 1979/1984), the perception of social psychological states (e.g. emotion) through nonverbal interactions (e.g. walking) is implied to serve some important purpose to the individual. Perceiving the emotional status of a walking individual allows the perceiver to react appropriately e.g. run away from an approaching angry person. Perceiving the emotional status of a walking individual thus affords survival-prolonging behaviour. Gibson’s ecological theory of visual...
perception is thus suitable for investigating the perception of different emotions through walking style.

Congruent with ecological theory, the alarm hypothesis (Walk & Homan, 1984) states that individuals can perceive more accurately and easily the emotions that are critically important for our own survival (e.g. anger or fear). The alarm hypothesis could be explained through ecological theory as the attunement and adaptation of our species’ perceptual systems because of its adaptive function. In this study it will be tested whether the alarm hypothesis (Walk & Homan, 1984) holds for the perception of different emotions through walking style. Ecological theory can be used to provide many generic hypotheses which are not specific to a certain species or a certain environment. However, the emotion-specific predictions derived from the alarm hypothesis (Walk & Homan, 1984) will strengthen the use of ecological theory (Gibson, 1979/1984) in this research by providing more specific predictions of how the different emotions may be perceived through walking style, specifically for the context of human to human interaction.

2.2.2. Brunswik’s lens model.

There are other competing theories in the investigation of the perception of biological motion. Some researchers adopt Brunswik’s Lens Model (1955) to investigate the perception of psychological traits from physical movement (Borkenau & Liebler, 1992, 1993a, 1993b, 1995; Gangestad, Simpson, DiGeronimo, & Biek, 1992; Sakaguchi & Hasegawa, 2006). Brunswik’s Lens Model views organisms as intuitive statisticians, whereby the perceptual systems combine and
weigh the information obtained from multiple cues so an accurate judgement can be made. This is why Brunswik used the analogy of a convex lens focusing the perceptual information, hence the name ‘Lens Model’ (Castellan, 1973). Essentially Brunswik’s Lens Model is formulated from the correlations of a person’s physical movements with both judgements of their personality and their scores on personality tests. Brunswik’s Lens Model, like Gibson’s (1979/1986) ecological theory of visual perception, stresses the mutuality of the individual and the environment and thus in both theories it is posited that personality traits are directly perceived through ecologically valid cues. Zebrowitz and Collins (1997) argue that the value of Brunswik’s Lens Model’s for analysing the communicability of psychological traits through physical movements is limited because it would result in a “chaotic array of correlations” (p210), hence the need for a strong theoretical foundation (i.e. Gibson’s ecological theory of visual perception) from which to draw strong specific predictions. Gibson’s ecological theory, on the other hand, views the environment as containing an array of information which the perceptual systems merely pick up in its entirety, and then the perceiver attends to what is considered important. The perceiver therefore determines what is perceived based on their individual motivations (i.e. affordances). This theoretical difference is important when looking at the social domain, of which the perception of emotion is a part. In social interaction two individuals are in a dyadic relationship whereby both parties bi-directionally influence each other’s behaviour (Gibson, 1979/1986; Waugh, 2004). The perceiver thus determines what they perceive in the other individual movements because of their own affordances (e.g. a happy person perceiving another individual as happier than they are). The other individual will do likewise and the two individuals will together determine the course of the social interaction. Ecological
theory can therefore make stronger predictions of how different emotions will be perceived in walking style due to the relative importance of specific emotions to the individual’s needs. Brunswik’s Lens Model can make no such predictions because the theory does not account for the influence of the perceiver on the perception of other individuals in the environment.

Brunswik’s Lens Model (1955) is usually used for the perception of personality traits through movement. This implies that the model can only be applied for fairly stable characteristics, which is reflected by the methods used in applications of the model to particular settings (i.e. relating the scores of a personality scale to individual movements, Zebrowitz & Collins, 1997). Emotions are responses to environmental situations (Rottenberg et al. 2007) and thus are more accurately described as psychological states. As previously described, the perception of emotions through movement needs to be done in real time, which fits more closely with Gibson’s (1979/1986) ecological approach. Gibson’s ecological theory of visual perception will therefore be used over Brunswik’s Lens Model, to investigate the perception of emotion in walking style.

2.2.3. Theory of event coding.

Another competing theory of perception and action is the Theory of Event Coding (TEC; Hommel, Musseler, Aschersleben & Prinz, 2001), also known as the Theory of Common Coding (Scott Jordon, 2001). The basic premise of TEC is that perception and action are intimately linked because both perception and action rely on the same cognitive representations (Prinz, 1997). There is support for TEC’s basic premise from the neurological findings that the brain regions used to display
an action are identical to the brain regions used to perceive the same action (Adolphs, 2001; Blakemore & Decety, 2001). Hommel et al. argue that TEC and Gibson’s (1979/1986) ecological theory of visual perception are congruent at most levels. They argue that the main difference between the two theories is that TEC is a model based theory and explains how perception can be employed in the absence of action (offline). TEC’s ability to explain offline perception is why TEC is often associated with studies investigating the planning of action (Kim & Effken, 2001; Scott Jordan, 2001). On the other hand, according to Hommel et al. (2001) ecological theory is an information based theory and can only be employed when action accompanies perception (online), and can only explain some behaviours because the environment does not provide enough information to afford certain actions (e.g. planning the steps in a long-jump). Hommel et al. therefore takes the position that TEC is preferable to ecological theory because ecological theory can not explain the ability to perceive a potential action without the accompanying action (i.e. action planning). The criticisms raised by Hommel et al. will be addressed in turn.

The first criticism of Hommel et al. (2001) with respect to ecological theory, that it can only explain online perception, can be countered with Gibson’s (1979/1986) concept of affordances. A perceived affordance has many contributing factors (among them the perceiver’s motivation, intention and ability) which influence how the perceiver will perceive this part of the environment (e.g., an object) and it includes also potential actions, that is, ways how the perceiver could interact with it without actually executing the action. Thus ecological theory can explain perception without the corresponding action (Tipper, Paul & Hayes, 2006)
and its use for motor planning without the need of any kind of mental representation in the perceiver. In TEC offline perception is accomplished by activating a common code that is shared between the perception of an action (or an object/body part related to this action) and the pre-motor planning of this action. The action does not need to be executed; the common code acts as a mental representation of the action-perception event at an early motor planning stage. However, not all perception codes are common codes (Tipper et al., 2006), that is not all perceptual events have accompanying actions. There is no theoretical basis to explain why some perceptions have a corresponding action and others do not. This is a major weakness of TEC (Chaminade & Decety, 2001; Hochberg, 2001). Gibson’s (1979/1986) ecological theory provides the theoretical context to allow online and offline perception without the problematic distinction between shared and non-shared codes, since it does not anchor the perception-action link in (some kind of) representation in the central nervous system of the individual, but locates it through the concept of affordances in the individual-environment interaction. For example, when a child and an adult perceive a coconut at the top of a tree, the child may not act deeming their ability to retrieve the nut to be inadequate, whilst the adult may climb the tree because they are big and strong enough to succeed. However, both would perceive the affordance of the coconut to provide food and the tree to afford climbing, even if the child has never climbed a tree before. The perception of an affordance (i.e. perception of a potential action) therefore does not require any accompanying action to the perception of the environmental stimulus. Ecological theory thus explains how an individual can perceive the emotional state of another person through their walking style without necessarily feeling that emotion or walking with that particular walking style (e.g. the perceiver may not perceive any
affordance for interacting with the emotional walker). TEC has difficulty in explaining if an action will accompany the perception of potential actions or not, thus why ecological theory appears to be preferable over TEC for the present research.

Kim and Effken (2001) argue against the second criticism of Hommel et al. (2001), that ecological theory can only explain some behaviour because for certain situations the environment holds an insufficient amount of information to afford a specific behaviour. Kim and Effken believe that Hommel’s criticism stems from the claim that ecological theory does not account for future action planning. This is an indirect criticism on ecological theory’s position favouring direct perception over the cognitive representations of TEC. Kim and Effken rebut Hommel and colleagues’ criticism with Tau theory (Lee, 2006). Tau theory is a direct perception theory that explains how animals approach a given object in the environment (e.g. when a long-jumper approaches the take off mark). Tau refers to the time until contact and taudot refers to the rate of change, both of which can be perceived from environmental information (for a detailed explanation see Lee, 2006). Tau and taudot can then be used to calculate the potential consequences of the current action and thus gives the individual the opportunity to adjust the current behaviour in order to achieve the desired planned consequence (e.g. modifying the step routine before take off in a long-jump). Tau theory therefore supports Gibson’s proposition that perception is done in real time yet still accounts for the future planning of actions. Offline perception is therefore explained in ecological theory through the support of Tau theory. Hommel’s (2001) argument that TEC is preferable to ecological theory
because of the TEC’s ability to explain the planning of future actions is therefore not very convincing.

It is not the aim of this study to test these theories against each other, but rather to use the theory that can generate the strongest experimental predictions and provide an adequate framework to explain the results. Gibson’s (1979/1986) ecological theory of visual perception has therefore been chosen for this research over both the Brunswik’s Lens Model (1955) and TEC (Hommel et al. 2001), because ecological theory provides the strongest source for predicting how specific emotions are perceived through a person’s walking style.


Chapter 3

The Expression and Perception of Emotions from Human Biological Motion

Emotion, and the terms associated with emotion, will first be defined further before discussion of how different emotions are perceived. Emotion is defined as a multi-componential response to environmental stimuli that usually invokes changes in cognitive, experiential, physiological, and behavioural response systems (Rottenberg et al. 2007). Affect is an umbrella term for all emotional states and thus is used interchangeably with emotion in this research. In contrast to emotion, mood is a slower, longer lasting state that is usually less tied to environmental stimuli (Watson, 2000). Ekman (1992) describes six basic emotions: fear, disgust, anger, joy, sadness, and surprise. These basic emotions can be thought of as responses to environmental stimuli that have been shaped by evolution (Atkinson & Adolphs, 2005). For example, in the situation of being threatened with physical harm, the response of fear may prime behaviour associated with flight whilst anger may prime fighting behaviour. It should be noted that the aim of the present study is not to investigate the workings of different emotions. The focus of the present study is on how four different emotions (i.e. happiness, sadness, anger & fear) are perceived through walking style.

3.1. Theoretical Differentiation of Emotions

How do emotions differ according to theory? The Circumplex Model has often been used to describe different emotions relative to each other in a constructed
affective space (Larsen & Diener, 1992; Pollick et al., 2001; Russel, 1980; Stevens, Glass, Schubert, Chen & Winskel, 2007). The circumplex model of emotion divides the affective space into two orthogonal bipolar dimensions. An emotion that sits at an extreme on one dimension is correlated highly with other emotions that sit nearby in the affective space, have no correlation with emotions that sit 90° away, and correlate inversely with emotions that are situated directly opposite in the circle (Larsen & Diener, 1992).

Whilst the circumplex model was originally created to distinguish between the felt/self-reported emotions of an individual (Russell, 1980), much research has since used the circumplex model to distinguish between the perception of different emotions (Larsen & Diener, 1992; Pollick et al., 2001; Stevens et al., 2007). The utility of the circumplex model for emotion perception research is also supported by the neurological evidence which has found the expression of different emotions activate the same brain areas as the perception of those same emotions (Adolphs, 2001; Blakemore & Decety, 2001). Furthermore, emotion expression and perception both play an important but dynamic role in social interaction. When two people are engaged in social interaction, they are experiencing a dyadic relationship whereby the behaviour of person A continually influences the behaviour of person B and vice versa (Blake & Shiffrar, 2006; Waugh 2004). Thus there is a dyadic relationship between the felt emotion of a person and the perceived emotion of that person by another. For example, when perceiving anger in an approaching person, the perceiver may react by experiencing fear and flee. Whether the emotions depicted in the circumplex model describe the felt emotion of the walker or the perception of the walker’s emotion by another person depends on who is specifically being described
(i.e. the walker or the perceiver). Emotion is therefore discussed in this research without reference to the felt experience or the perception of the emotion unless the description specifically refers to either the walker or the perceiver.

A limitation of the circumplex model is that it constrains the description of different emotions to a 2-dimensional space. The dimensions chosen to describe that 2-dimensional space must therefore be chosen with careful consideration to theory and the requirements of the research (Larsen & Diener, 1992). Alternatively, a combination of multiple different dimensions (e.g. 3-, 4-, or 5-dimensional space) may describe the relationship between different emotions more adequately than the two dimensions of the circumplex model. However, additional dimensions make the interpretation of results considerably more difficult. Furthermore, it is difficult to determine the minimum number of dimensions that are needed to conclude that affective space has been adequately described. The circumplex model is therefore limited to a simpler 2-dimensional space whereby the individual dimensions used can be modified according to theory and the requirements of the research. Consequently, the circumplex model has been used extensively in past research on emotion expression and perception (Larsen & Diener, 1992; Pollick et al., 2001; Russel, 1980; Stevens et al 2007).

No two dimensions in a circumplex model are superior to any other selected dimensions. The structural validity of the circumplex model depends on the clear description of the dimensions chosen, on how those two dimensions are measured, and the emotional adjectives used (Larsen & Diener, 1992). The selection of which
dimensions to use and how they should be labelled and measured should therefore depend on the objectives of the study.

The two dimensions selected in this study to discriminate different emotions are the hedonics dimension and the approach/withdrawal dimension (see figure 1). The hedonics dimension (also known as the pleasantness or valence dimension) separates felt emotions into positive and negative emotions (Lane et al., 1997). Positive emotions are generally considered pleasant to experience (e.g. happiness, surprise), whilst negative emotions are generally considered unpleasant to experience (e.g. anger, fear, sadness). Both positive and negative emotions on the hedonics dimension have been found to aid an organism survive and adapt to situational and lifestyle demands (Buck, 1988; Fredrickson, 2003). The hedonics dimension is thus congruent with the ecological perspective adopted for this study.

Figure 3.1: A circumplex model of how four different emotions can be differentiated according to the hedonics dimension and the approach/withdrawal dimension.
The second dimension that emotions are discriminated upon in this study is the approach/withdrawal dimension (Davidson, Ekman, Saron, Senulis, & Friesen, 1990; Feldman Barrett & Wager, 2006; Watson, Wiese, Vaidya & Tellegen, 1999). Some felt emotions (e.g. happiness, anger) facilitate approaching behaviour in an individual, whilst other felt emotions (e.g. fear, sadness) facilitate withdrawing from the environmental stimulus. The approach/withdrawal dimension is particularly important for this research for two reasons: 1) This study is investigating how affect is perceived through walking. Walking is a locomotive behaviour used to either approach or withdraw from an object in the environment. 2) The approach/withdrawal dimension is the most relevant means of perceptually distinguishing between the felt emotions of a walker in Gibson’s (1979/1986) ecological theory of visual perception. It is necessary to know if the person walking towards me is angry (therefore intending to hurt me) or happy (therefore intending to welcome me) so I can react to their movements appropriately. Perceiving the emotion felt by the walker will then determine whether I approach this person in friendship or withdraw from the person out of caution. The affordances associated with the perception of specific emotions are therefore more applicable to the approach or withdrawal of a walker. The approach/withdrawal dimension is therefore suitable to the current studies aims and theoretical background.

It should be noted that alternative circumplex model dimensions have previously been used to investigate emotion perception. One such dimension that is commonly used is the activation dimension (also known as the arousal dimension, Paterson, 2002; Pollick et al. 2001; Russel, 1980; Stevens et al. 2007; Wallbott, 1998). High activation emotions (e.g. happiness) are energetic and produce high felt
arousal in the individual feeling the emotion. On the other hand, low activation emotions (e.g. sadness) are noticeably less energetic and produce low felt arousal in the individual. However, the activation dimension represents a narrower aspect of the approach/withdrawal dimension (Watson et al. 1999). The basic adaptive functions of high activation emotions are to motivate the individual towards approaching and obtaining resources (e.g. food, sexual partners). In contrast, low activation emotions serve the purpose of inhibiting the individual’s action in favour of perceiving and avoiding potential environmental dangers/aversive stimuli. The activation dimension thus describes the motivation for approaching or withdrawing from environmental stimuli. The approach/withdrawal dimension is being used in this research and thus the inclusion of the activation dimension would be superfluous.

As previously discussed, the circumplex model may also be used to understand how different emotions are expressed and therefore perceived. The primary focus of this thesis is on how emotions are perceived with a secondary focus on how emotions are expressed from walking style. There is however, an assumed congruence between how an emotion is expressed and how the same emotion is perceived, which is supported by the neurological evidence (Adolphs, 2001; Blakemore & Decety, 2001). Knowledge of how different emotions are expressed thus gives an indication for how they are perceived. The next section will therefore discuss some of the methods for expressing the felt emotion of an individual.
3.2. Darwin: The Expression of Different Emotions through Human Movement

Emotion can be expressed and therefore presumably perceived through movement. Darwin (1872/1999) argues that all actions that are often accompanied by a state of mind are immediately recognized as expressive. The perception of emotions in others appears to be a universal ability and is argued to serve an adaptive function in the species (McArthur & Baron, 1983), which is in accordance with both the Darwinian and the Gibsonian perspectives. Emotion is a basic experience for all humans and accompanies almost everything we do (Damasio, 1998). Therefore emotion is a mental state that may be expressed and perceived through a large number of movements.

Darwin (1872/1999) describes some specific movements that people use to express specific emotions. Darwin described the expression of intense joy (which is comparable to happiness) through energetic purposeless movements, such as dancing, stamping and laughter. Atkinson, Dittrich, Gemmell and Young (2004) supported Darwin’s descriptions when most actors attempting to express happiness skipped and danced about with their arms raised (28 out of 30 actors). Furthermore, cheerfulness was also described to be expressed through an upright posture and is described by Darwin as the antithesis of a person expressing sadness. Darwin also describes the expression of sadness through lethargic movements, such as the drooping of the head and passive bodily movement. Atkinson et al. (2004) also supported Darwin’s description of sadness with their actors displaying sadness mainly through the dropping of the head (27/30)
In contrast, Darwin (1872/1999) explains that an individual experiencing anger diverts strength to the muscles in preparation for action. Anger is therefore expressed through energetic, approaching, and erect body movements. The expression of anger is very similar to the posturing behaviour of two males (Grossman, 1996). Since the aim of posturing is to appear intimidating and an angry man is more likely to attack, it is not surprising that posturing behaviour has some common elements with the expression of anger. The link between an individual experiencing anger, posturing and potential attack is further supported by Atkinson et al. (2004) who found that actors expressing anger usually (24/30) displayed expansive approaching movements. Expansive movements will make an individual appear larger and thus more dangerous and physical attacking behaviour usually requires approaching the target.

Fear on the other hand, is described by Darwin (1872/1999) as leading to a heightened state of perceptual awareness in order to perceive any oncoming threat. Therefore fear is likely to be expressed through perceptually alert movements such as wide eyes, looking around, or ready to spring from a crouch. Furthermore, individuals experiencing fear are likely to hold their hands out in front or to cover their head as if to ward off any damage to vital areas of the body (i.e. head or major organs). Atkinson et al. (2004) showed that actors expressing fear usually (29/30) displayed withdrawing movements and thus providing more support for the approach/withdrawal dimension used in the current research.

Nevertheless, it should be noted that there is a distinction between the expression of felt emotion and the perception of emotions in others. Human beings
are highly social creatures (Blake & Shiffrar, 2006) and sometimes in social interaction it is important to conceal the display of one’s felt emotions (e.g. to produce greater in-group harmony) or to intentionally deceive others of one’s felt emotions (e.g. the posturing of two males in conflict). Thus the emotion that an individual is perceived by another as feeling may be incongruent with the actual emotion that is felt by that person (Rottenberg & Gross, 2003). In Gibson’s (1979/1986) ecological theory of visual perception, perception is assumed to be veridical but errors and bias may occur (McArthur & Baron, 1983). Errors occur when one’s knowledge of the world, or perceptual attunements, do not permit the perception of the underlying emotion (e.g. a trusting child may not have learnt to perceive a sly smile). Bias on the other hand is due to selective attention or the perceived affordance of the individual (e.g. a happy person might perceive others as happier than they really are). Ecological theory argues that the environment holds sufficient information for a perceiver to make a correct perceptual judgement of another individual’s emotional state (McArthur & Baron, 1983). Ecological theory therefore argues that the perception of the emotional state of another individual is essentially accurate, especially for emotions with a strong adaptive function (e.g. anger), but sometimes a perceiver may be incorrect with their perceptual judgements due to other contributing factors (i.e. error and bias).

The focus of this study is on how different emotions are ‘perceived’ through walking style and not whether a particular walking style expresses the ‘felt’ emotions of a walker. This study will be using actors to express different emotions in walking style thus it is assumed that the walkers will not actually feel the emotions they intend to express. Nevertheless it is assumed in this study that the
perception based results will be representative of how individuals express different felt emotions in their gait. Follow up studies will be needed ultimately to test and verify this assumption.

Further support for this study’s assumption and for Darwin’s (1872/1999) argument that emotions are mental states that can be expressed and therefore perceived through bodily movement can be found in both the behavioural and neuroimaging literature. Different emotions can be expressed through facial expressions (Adolphs, 2006; Ekman & Oster, 1979; Vaughn Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007) and/or body movements (such as walking, Chouchourelou, Matsuka, Harber & Shiffrar, 2006; Dittrich et al. 1996) of the individual feeling the emotion. Each basic emotion activates specific brain areas (Atkinson & Adolphs, 2005; Feldman Barrett & Wager, 2006). Furthermore, the method of expression (i.e. face or body) activates distinct brain systems (Buccino et al. 2001) which imply that research on facial expression of emotion may not generalise to bodily expression of emotion (such as walking). Thus there are neurological differences between the expressions of different emotions through different actions.

3.3. Neurological Evidence for the Perception of Emotion through Biological Motion

Social communication relies on the ability to communicate one’s intentions and emotional feelings to others and subsequently for others to accurately perceive the expressed intentions and emotions (see Blake & Shiffrar, 2006, for a review on the extensive and still quickly growing body of literature on this point). It has been
shown, that the perceiver recognises the expressed emotions via activation of the same brain areas that are used for expressing those same felt emotions (e.g. superior temporal sulcus, right somatosensory cortices and other brain areas specific to the emotion being perceived, Adolphs, 2001; Blakemore & Decety, 2001). The neurological link between the perception of an emotion and the expression of an emotion through biological motion, suggests that the perceptual strategies used to identify different emotions in bodily movements inform as to the actual methods of expressing those same emotions through biological motion.

There is neurological evidence that emotions can be perceived through walking style in particular. Heberlein, Adolphs, Tranel and Damasio (2004) compared brain damaged patients that were impaired in their ability to recognise emotions to patients that were impaired in their ability to recognise personality and to patients impaired in both abilities. The authors found the right somatosensory cortices were identified to be vital for the judgments of emotions in point-light walkers. The right somatosensory cortices are the same areas which have been identified in other neurological studies to be vital for emotional recognition (Adolphs, 2001; Adolphs, Damasio, & Tranel, 2002; Blakemore & Decety, 2001; Winston, O’Doherty, & Dolan, 2003).

A major shortcoming of the study by Heberlein et al. (2004) is their only justification for using point-light walkers were that point-light walkers are “known to convey… emotion…information” (p1143) with no referential support. The authors’ argument rested on the assumption that emotions can be perceived from other biological movements (e.g. dance, Dittrich et al. 1996; door knocking, Pollick
et al. 2001) therefore emotions must also be perceived from point-light walkers. The reasoning is not valid until specific support has been found that emotions can be perceived from point-light walker stimuli. Consequently, a primary aim of this thesis research is to test whether emotions can indeed be perceived from point-light walker stimuli. Furthermore, there was no description on how the point-light walker stimuli used by Heberlein et al. (2004) was recorded or what instructions the walkers received before their recording. No critique can therefore be made regarding the quality of the stimuli used. It can only be assumed that the point-light walker stimuli successfully displayed different emotions because the results of the study by Heberlein (2004) showed that the brain lesions in the right somatosensory cortices (i.e. the region associated with emotion recognition) resulted in detrimental identification of the expressed emotion thus supporting their original hypothesis. The logic is circular. The results are supported if the point-light walkers successfully display different emotions but the quality of the point-light walker stimuli is only validated because the results support the original hypothesis. The study is reliant on an unjustified assumption. The present study aims to justify the assumption made by Heberlein et al. (2004) by investigating whether different emotions can be perceived from point-light walker stimuli.

However, Chouchourelou et al. (2006) also used point-light walkers to investigate whether the neurological structures related to the analysis of human movement (i.e. superior temporal sulcus) are highly interconnected with those related to the analysis of emotions (i.e. amygdala). The authors recorded point-light displays of two actors displaying the emotions happiness, sadness, anger, fear, and neutral (i.e. the same emotions that are being investigated in the current research).
The point-light displays were validated through inter-rater agreement (>83%). The point-light walkers were shown to perceivers within a mask of visual noise (i.e. random dots moving identically to the walker). Perceivers were thus required to identify which emotion they saw (experiment 1 and 3) and whether a walker was present in the mask (experiment 2). Chouchourelou et al. (2006) found that perceivers were most sensitive to the perception of anger, though anger had significantly higher false alarm rates (i.e. incorrect categorizations) than either neutral or any of the other emotions. The authors argued that the perception of anger is more important to our survival because of the potential threat an angry person affords. Their argument is congruent with the alarm hypothesis (Walk & Homan, 1984). Furthermore, Chouchourelou et al. (2006) found that when a walker was absent from the mask of visual noise, perceivers still reported seeing an angry walker significantly more than any other emotions. Angry walkers were characterized by high velocity movements which were thus replicated in the mask of visual noise. High velocity movement therefore appears to carry some of the information communicating the anger displayed in a walker’s movements. Chouchourelou et al. (2006) therefore showed that different emotions can be perceived through walking style and thus supporting the assumption of Heberlein et al (2004).

Despite Chouchourelou et al. (2006) not directly measuring neurological activity, their hypotheses were drawn from the neurological literature and tested with behavioural experiments. Furthermore, their findings support the assumption originally made by Heberlein et al. (2004) that specific emotions can be displayed and perceived through walking style. However, the findings of Chouchourelou et al.
(2006) does not support whether the particular point-light walkers that Heberlein et al. (2004) used in their study validly displayed specific emotions through their walking style. Thus it can be concluded that specific emotions can be displayed and perceived through walking style though careful thought must be given to the methodology for recording walkers displaying different emotions.

This section has shown that there is neurological evidence supporting the expression and perception of emotions from walking style. However, a deeper understanding of how emotions are perceived from walking style will also inform as to the gait features used to express those same emotions. The next section will therefore seek to discuss some of the perceptual mechanisms that perceivers use to pick up on emotion-laden information displayed through bodily movement.

3.4. Perception of Emotions through Bodily Movement

There is much evidence that emotions can be perceived through movement. Atkinson et al. (2004) found that different emotions can be reliably identified through acted out movements in both point-light and full-light displays. The movements that were acted out were open to the actor’s individual interpretation. However, the actors expressed the different emotions through some consistent patterns. For example, actors expressing sadness dropped their heads in 27 out of 30 occasions. This pattern is congruent with Darwin’s (1872/1999) descriptions of the body postures associated with sadness. Furthermore, anger was expressed through expansive movements to the camera, and often included the stamping of feet. Stamping feet may also be a method that the walkers in the present study may use to display anger through walking movements. In contrast fear was expressed through
cowering movements away from the camera. The difference between the movements for expressing anger (i.e. approaching movements) and expressing fear (i.e. withdrawing movements) provides further support for the use of the approach/withdrawal dimension of the circumplex model used in this research (see section 3.1.).

Atkinson (2007), Atkinson (in press), Atkinson et al. (2004) and Dittrich et al. (1996) have all collected comparable data on the correct identification rates of different emotions in both full-light and point-light formats. Atkinson et al. (2004) found that both anger and fear were identified correctly significantly more in the full-light movies compared to the point-light movies. There was no significant difference between the display formats for the emotions happy and sadness. Though all emotions were still perceived very easily with anger displayed through point-light display have the lowest correct identification rates (71.94%) and fear displayed through full-light display having the highest correct identification rates (91.11%). These results therefore argue against the alarm hypothesis (Walk & Homan, 1984: see section 2.2.1. for detailed explanation) that will be tested in the present research. Furthermore, the influence of display format (i.e. full-light vs. point-light) on the perception of specific emotions through walking style will be statistically compared in the current research.

Atkinson et al. (2004) also differed the levels of exaggeration in the expression of different emotions. They found that exaggerating the expressive movements for each emotion improved the identification of those emotions by perceivers, except for sadness which reduced the rates of correct identification. The authors also found that
the ratings of emotional intensity in the expressive movements increased as the
movements increased in the level of emotional exaggeration. This finding indicates
that expressing different emotions through different levels of intensity may be
beneficial. Therefore the different levels of emotional intensity will be statistically
compared throughout the present research.

Furthermore, Atkinson (in press) showed the importance of global motion
perception to the identification of emotions from both full-light and point-light
displays of bodily movement. The visual perceptual abilities of autism spectrum
disorder (ASD) participants were compared to a group of typically developed
participants for a number of tasks. Both groups of participants were able to identify
basic emotions (i.e. happiness, sadness, anger, fear and disgust) displayed through a
variety of biological movements above chance levels. However, the ASD group
were not as successful at identifying the displayed emotions anger and happiness.
Furthermore, the ASD group showed deficits in their ability to detect the uniformed
directional movement of a proportion of dots in a dense (approximately 750 x 1mm
dots) screen of visual noise (i.e. motion coherence threshold). Linear regression
analyses showed that motion coherence threshold significantly predicted the emotion
identification rates in both full-light and point-light displays of ASD individuals but
not typically developed individuals. The impaired ability to perceive emotional
displays through bodily movement of ASD individuals is thus partly due to their
impaired ability to perceive uniformed motion. Consequently, emotions are likely
displayed, and therefore perceived, through co-ordinated variations of biological
motion such as walking styles.
Dittrich et al. (1996) also showed that emotions could be successfully shown and recognised through both full-light and point-light displays of dance. But when the displays of the dancers were inverted recognition dropped to near chance levels, though still significantly above chance. This supports the applicability of the concepts adaptability and attunement (Gibson, 1979/1986) to the perception of emotion through movement. Perceivers are generally not exposed to inverted dancers in the environment. The visual perceptual system has therefore adapted and attuned to perceive emotion through ecologically valid movement, despite the visual stimulus being reduced to point-light display. Though, there is a fundamental difference between dancing and walking. Dance is an intentionally expressive activity whereas walking usually is not.

Emotion can also be efficiently perceived from actions that are not intended to be emotionally expressive. Pollick et al. (2001) found that affect could be accurately perceived from point-light displays of an arm knocking. Perceived affect from the knocking movements corresponded to two dimensions: activation and pleasantness. The pleasantness dimension is identical to the hedonics dimension used in this study (i.e. they differ in label only). The authors argued that activation is a formless cue that is perceived solely through the kinematics of the limb movement, whilst pleasantness is perceived through the phase relations of the different limb segments. Whilst knocking actions occur in the everyday life of the normal person, it is only the movement of a small part of the body. Using a full body movement (i.e. walking) could provide additional cues to assist with the perception of emotion. The perceiver of a walker will have access to an assortment of different kinematic cues that they can draw upon to facilitate perception (Westhoff, 2005). The study of
walking will combine the advantages of using a full-body display, like the dancers
used by Dittrich et al. (1996), with the decreased intentionality for expressing
emotions, like the knocking movements of Pollick et al. (2001). This research is
therefore going to investigate the perception of different emotions (i.e. happiness,
sadness, fear, and anger) through the biological movement of walking. First it would
seem prudent to discuss some of the variables that could possibly influence the
perception of different emotions through biological motion.

3.5. Variables that Influence the Perception of Emotion

3.5.1. Influence of walker gender on the perception of emotion.

Expressing emotions through facial expressions and bodily movements activate
distinct brain systems (Buccino et al. 2001). Nevertheless, variables that influence
the perception of emotions from facial expressions may also influence the perception
of emotions from bodily movement. This section will explore one such variable,
walker gender; (Fabes & Martin, 1991; Grossman & Wood, 1993; Plant, Hyde,
Keltner & Devine, 2000; Swerts & Krahmer, 2008; Vaughn Becker et al. 2007) and
the influence it can exact on the perception of different emotions through bodily
movement as derived from our knowledge of the perception of emotions from facial
expressions.

Vaughn Becker et al. (2007) investigated the confounded nature of gender and
emotion in facial expressions. They found through a series of seven experiments that
anger was more quickly and accurately perceived on male faces than female faces.
Also, happiness was faster and more accurately perceived on female faces. The
study’s results indicate that this confound between gender and emotion is likely
caused by the physical structure of the face. Male faces have several architectural structures that are different to female faces (e.g. lower brow, squarer jaw; Bruce, Burton, Hanna, Healy, Mason et al. 1993).

Darwin (1872/1999) explained that anger is expressed by: a) the furrowing of the eyes by the centre of the brow being strongly drawn down, b) a compressed mouth, c) flared nostrils, and d) glaring eyes. Darwin’s description of the facial expression of anger has been verified through human perception studies (Ekman & Friesen, 1976; Massaro & Egan, 1996) and through the creation of neural networks that can identify specific emotions from facial expressions (Padagett, Cottrell, & Adolphs, 1996). The cues associated with expressed anger are also more likely to be seen on male faces because of architecture of the male face. Male faces in general have: a) larger and heavier brows giving the impression of furrowing eyes; b) squarer jaws giving the relative impression of a compressed mouth; c) larger noses and thus giving rise to the perception of flared nostrils (Bruce et al. 1993). The glaring eyes are the only method of expressing anger through facial expressions (Darwin, 1872/1999; Ekman & Friesen, 1976; Massaro & Egan, 1996) that are not influenced by gender specific facial architecture.

Happiness on the other hand is expressed by (Darwin, 1872/1999; Ekman & Friesen, 1976; Massaro & Egan, 1996; Padagett et al. 1996): a) the raising of the upper lip which causes the nose to wrinkle and consequently be perceived as shorter, (b) the eyes are narrowed (which is in direct contrast to the glaring eyes of anger), and (c) the retracting and raising of the corners of the mouth which cause the narrow eyes to sparkle. The expression of happiness through these facial features gives the
individual a face that resembles a baby’s face. Females who have rounder neotenous architecture in their faces thus more closely resemble a baby’s face (Vaughn Becker et al. 2007). Bowlby (1969) argues that human adults have a strong predisposition towards positive approach laden behaviour towards babies. Berry and McArthur (1986) also found that adults with baby-faced features received more positive evaluations and were perceived as being less dominant. Anger is an emotion used to dominate over others and therefore a less dominant person may be perceived to be less angry. Female, baby and happy faces therefore seem to share similar characteristic features.

However, walking is clearly different to facial expressions and the perception of different emotions from facial expressions uses a different brain system to that used for the perception of emotions through bodily movement (Buccino et al., 2001). Thus the results of Vaughn Becker et al. (2007) may not generalise to cover the expression and perception of emotions through walking style. However the gender of a walker is likely to still influence the perception of different emotions through walking style because males and females have distinct walking styles. Any specific emotion that is expressed through gait movements (e.g. anger) that are similar to a gender specific walking style (e.g. male) are likely to bias the perception of that emotion towards the gender of the walker (i.e. male walkers are more likely to be categorised as displaying anger).

Troje (2002) found that males, relative to females, walked with greater lateral sway of the body and with their elbows out. Male gait appears to make the walker look bigger and thus more dangerous than they are, very similar to the
posturing of two competing individuals (Grossman, 1996). Anger is the approach emotion directing fight behaviour and thus the posturing of two individuals are likely to be projecting an element of anger in their implied non-verbal threat. Thus anger is likely to be expressed through a walking style that increases the perceptual size of the walker and to make the walker seem more dangerous. Thus large, forceful movements are predicted to be seen in an angry walk (e.g. long fast stride, square shoulders, and straight posture). Furthermore, because the hypothesised similarity between male specific gait and angry gait, it is predicted that male walkers will be categorised correctly as displaying anger significantly more than female walkers.

On the other hand, human females are more likely to adopt a tend-and-befriend approach (Taylor, Klein, Lewis, Gruenewald, Gurung et al. 2000) compared to the fight-or-flight approach adopted by males (Trivers, 1985). And thus females would wish to appear less threatening/dominating to facilitate greater cooperation between themselves and others. Such reasoning explains why Troje (2002) found that female gait exhibited size reducing kinematics (i.e. elbows in, small steps, and greater pivoting of the shoulders), similar to the submitting behaviour exhibited by an individual who wishes to communicate that they are no threat to a competitor (Grossman, 1996). Furthermore, Vaughn Becker et al. (2007) found a perceptual bias towards happiness in female faces. The display of happiness facilitates cooperative behaviour in other perceiving individuals (Fredrickson, 2003). Therefore, it is predicted that female walkers will be categorised correctly significantly more than male walkers as displaying happiness.
As can be seen, the results of Vaughn Becker et al. (2007) can theoretically be
generalized to the perception of emotions though walking style. In addition to
providing evidence on which to base hypotheses about emotion specific gait
kinematics, Vaughn Becker et al. (2007) introduces the need to investigate the
possible influence of walker gender on the perception of specific emotions.
Specifically, it is predicted that anger will be identified more correctly and more
reliably in male walkers as compared to female walkers. It is also predicted that
happiness will be identified more correctly and more reliably in female walkers as
compared to male walkers.

3.5.2. Influence of ecological importance on the speed of emotion perception.

Certain emotions appear to be identified faster than others. The ecological
perspective (Gibson, 1979/1986) would argue that an individual’s perceptual
systems would adapt and attune to perceive an emotion that is increasingly
important to that individual’s needs. It can therefore be assumed that the more
important the perception of a specific emotion is to our survival then that emotion
should be perceived quicker than specific emotions that are less important to our
survival. This argument, which is congruent with the alarm hypothesis (Walk &
Homan, 1984), would thus predict that anger followed by fear should be identified
the quickest.

This assumption is supported by Vaughn Becker et al. (2007) who found that
angry male faces and happy female faces were identified faster than happy male
faces and angry female faces. Vaughn Becker et al. (2007) argued that there was a
confounded nature between the perception of emotions and the gender of the face.
The authors argue that the origin of this confound lies partially in the way different genders deal with threatening situations. As previously discussed, human females are more likely to adopt a tend-and-befriend approach (Taylor et al. 2000) compared to the fight-or-flight approach adopted by males (Trivers, 1985). Therefore the perception of an angry male is more likely to afford danger and thus it is not surprising that they are perceived quickly in order to avoid the possible danger. Also, the perception of a happy female may afford assistance thus it is not surprising that they are perceived quickly in order to capitalise on the potential gain.

However, alternative predictions can be made from another argument using the ecological perspective. The argument posits that conscious identification of negatively valence stimuli will be slower than positively valenced stimuli because the mind’s resources are redirected towards action, instead of conscious awareness, for negatively valenced stimuli. Thus a walker displaying a negative emotion (e.g. anger) may not be consciously identified faster than other emotions but the mind would have diverted resources to the body so the body can react appropriately (e.g. fight-or-flight response). This argument is supported by Eastwood, Smilek, & Merikle (2003) who found that perceivers take longer to count negatively valenced faces in a crowd compared to positively valenced faces. This is congruent with the findings of De Sonneville, Verschoor, Njiokiktjien, Op het Veld, Toorenaar, and Vrancken (2002) who found that happy faces were identified faster than all negatively valenced faces (i.e. sad, anger, and fear). The opposite prediction can therefore be made regarding how fast perceivers will identify specific emotions in the walkers. It can thus be predicted that happiness will be identified faster than
sadness, anger and fear. If this argument can be applied to the alarm hypothesis, it can then be predicted that anger will be identified the slowest and followed by fear.

3.5.3. Adaptation aftereffects of emotion perception.

Adaptation aftereffects are another variable that could possibly influence the perception of different emotions in walkers. Adaptation aftereffects describe the extent to which exposure to the preceding stimuli influences the perception of the following stimuli (Schrater & Simoncelli, 1998; Troje, Sadr, Geyer & Nakayama, 2006). Adaptation effects have been found in a variety of contexts related to the visual perception domain (face shape, Webster & Maclin, 1999; facial expressions of emotion, Hsu & Young, 2004; walker gender, Jordan, Fallah & Stoner, 2006; Troje et al. 2006).

Hsu and Young (2004) showed adaptation aftereffects occurred when correctly categorising the emotion displayed through facial expressions. After adapting to an emotional facial expression (e.g. happiness) for 5s, the following display of the same emotion resulted in significantly lower correct identifications. This is known as an inhibition effect. The inhibition effect was supported for each of the three emotions (i.e. happiness, sadness, and fear) studied. The inhibition effect was robust enough to still be in effect following changes in the stimuli used (both the faces and the size of the faces) and after a short temporal gap (i.e. 1s). The study supported the theoretical explanation that after perceiving specific stimuli (e.g. a happy face) the neurons activated during that perception become fatigued and thus become more difficult to immediately stimulate again therefore inhibiting subsequent perception of the same stimuli (i.e. a happy face).
Hsu and Young (2004) also found a facilitation effect between the correct identification of facial expressions for happiness and sadness. That is, after adaptation to a happy facial expression, subsequent sad facial expressions were identified correctly significantly more than any other emotion (and vice-versa). Happiness and sadness are theoretically opposite emotions in both the hedonics and the approach/withdrawal dimensions of the circumplex model adopted in this research. Inhibition of the identification of one emotion (e.g. happiness) will therefore facilitate the identification of the theoretically opposite emotion (e.g. sadness) due to a changing in the criterion used to discriminate between different stimuli (Stewart, Brown, & Chater, 2002).

No facilitation effect was found between fear and either happiness nor sadness (Hsu & Young, 2004). Nevertheless fear is also theoretically opposite to happiness (on both the hedonics and approach/withdrawal dimensions) and yet happiness was not identified correctly significantly more following adaptation to a fearful face (or vice-versa). This may be due to the role that fear plays in the fight-or-flight response (Cannon, 1932), as compared to the tend-and-befriend response (Taylor et al. 2000) which primarily involves happiness and sadness. Anger is theoretically opposite to fear regarding the fight or flight response and also the approach/withdrawal dimension of the circumplex model used in this research. The introduction of anger into the analysis of adaptation aftereffects may yield a facilitation effect between the perception of anger and fear.
As has been stated, expressing emotions through facial expressions and bodily movements activate distinct brain systems (Buccino et al. 2001). Nevertheless, the same adaptation aftereffects have been found in the perception of gender in point-light walkers (Jordan et al. 2006; Troje et al. 2006). Jordan et al. (2006) and Troje et al. (2006) both found that gender neutral point-light walkers were perceived as male after adaptation to an exaggerated female walker and were perceived as female after adaptation to an exaggerated male walker. Thus adaptation aftereffects can also be generalized to gait movements (which are the focus in this study).

Adaptation aftereffects have been found in the perception of emotions from facial expressions (Hsu & Young, 2004) and the perception of gender in point-light walkers (Jordan et al. 2006; Troje et al. 2006). Vaughn Becker et al. (2007) has highlighted that there is a confounded nature in the perception of emotions (specifically happy and sad) and with facial gender. Even though facial expressions and bodily expressions activate distinct neurological systems (Buccino et al. 2001), the findings of Troje et al. (2007) suggests that the adaptation aftereffect may be generalizable to the perception of emotions from gait movements. Therefore, in the present research the influence of adaptation aftereffects on the perception of specific emotions from walking style will be directly investigated.

The majority of the previous research has discussed the perception of specific emotions through different forms of biological motion (e.g. facial expressions, dance, knocking movements). However, the current research is specifically focusing on the perception of specific emotions through walking style.
The use of gait as the biological motion of interest introduces a number of factors that must be considered for the current research. Some of these factors will be discussed in the next section.
Chapter 4

The Utility of Walking Movements for Perception Research

Virtually everyone walks. The average person could be accurately described as an expert at walking. Despite this expertise, every person still has their own individualised walking style. The walker has minimal cognitive awareness to the actual movement process of walking. Walking is therefore a prime phenomenon for the investigation of involuntary displays of a person’s characteristics and emotional states through movement. The literature contains a wealth of information on the perception of various attributes and states in walking. Some of these include: sex identification (Troje, 2002; Yamasaki, Sasaki, & Torii, 1991), person identification (Cutting & Kozlowski, 1977; Loula, Prasad, Harber, & Shiffrar, 2005, Westhoff, 2005), discrimination of geographic residence (Bornstein & Bornstein, 1976), social status (Schmitt & Atzwanger, 1995), victim potentiality (Gunns et al. 2002; Johnston et al. 2004; Winkel & McCormack, 1997), and emotions (Chouchourelou et al. 2006; Montepare, Goldstein, & Clausen, 1987). A walking style clearly carries an assortment of different information about the person. Some of these studies and how they may influence the current research will now be discussed.

4.1. *Perception of Psychological Attributes through Walking Style*

Other than emotions, many different walker characteristics and psychological states appear to be perceivable from walking style. A person’s social status can be perceived through walking style. Schmitt and Atzwanger (1995) found that males walked faster when they possessed higher social status. Social status did not influence the walking pace of females. The authors recorded walkers who were
uninformed about the study or that they were being measured. Each walker was unhampered and without luggage as they walked a 20 meter path along 1 of 9 different streets in Vienna, Austria. The streets were similar in regards to buildings, footpaths, shop windows, pedestrian flow and traffic. One observer chose which subject to record and two alternative observers measured the time it took for the walker to walk the pre-recorded distance. Walkers were approached and interviewed after their walking pace was recorded. Bornstein and Bornstein (1975) used a similar methodology when they found that walking pace increased with the size of the population. That is individuals who resided in the city walked faster than individuals who resided in a town. The authors measured walkers in the main streets of 15 cities and towns in six countries in Europe, Asia, & North America. Observed walkers were timed over the pre-measured distance of 50 feet (15.24m). This methodology for recording gait has the advantage of greater ecological validity. The walkers were in their natural environment and they were unaware that they were being measured. However, the trade off from having such high ecological validity is there is a decreased degree of experimental control. For example the walkers recorded in both studies were free to wear any clothes that they wished. Clothing and footwear changes a person’s walking style (Gunns et al. 2002) and thus the walkers in both Schmitt and Atzwanger’s (1995) and Bornstein and Bornstein’s (1975) studies may have influenced the results with the clothes they wore. For example female walkers in a city may be more inclined to wear high heeled shoes than females in a town. Wearing high heeled shoes reduce the stride length of a walker thus reducing their walking pace (Sutherland, 1994). Thus a balance is needed in the current research between the need for ecological validity and for experimental control. This balance will be maintained in the current research by normalizing the clothing and
environmental conditions of the walkers that will be recorded but walkers will be free to express the different emotions through gait movements of their own choosing.

More specifically, individual persons can be identified from point light displays of their walking style (Beardsworth & Buckner, 1981; Cutting & Kozlowski, 1977; Jokisch, Daum, & Troje, 2006; Westhoff, 2005). Cutting and Kozlowski (1977) found that perceivers could identify individual walkers shown in point-light display significantly above chance. The authors recorded point-light displays of six individuals walking back and forth in front of a camera. The same six walkers served as perceivers who were required to identify each individual walker from the point-light displays. All walker/perceivers were familiar with each other. Nevertheless, perceivers gradually improved their correct identification rates over the course of the task even though no feedback was given from the researchers. Despite observers being familiar with each other prior to the experiment they were not familiar with each others movements as shown through point-light display. Such a finding gives support to Gibson’s (1979/1986) concept of attunement whereby perceivers need prior exposure to the display format of the individual’s gait movements in order to attune their senses to accurately perceive the identity of an individual through their walking style.

However, Beardsworth and Buckner (1981) criticized Cutting and Kozlowski (1977) for failing to control for the number of guesses that perceivers made in favour of individual walkers. Beardsworth and Buckner (1981) therefore replicated Cutting and Kozlowski’s (1977) study but constrained the number of guesses that
could be attributed to each walker (including themselves). Therefore the six walkers were shown in a total number of 60 presentations thus each walker was limited to 10 categorizations by each perceiver. In contrast to the findings of Cutting and Kozlowski (1977), Beardsworth and Buckner (1981) found that perceivers were significantly better at identifying themselves as opposed to other walkers. However, in addition to constraining the number of guesses perceivers could make, the authors also used a more complex display pattern and longer display durations. Therefore, conclusions can’t be made about which of these manipulated variables produced the difference in the two studies results.

Both Cutting and Kozlowski (1977) and Beardsworth and Buckner (1981) displayed individual walkers from a sagittal perspective. Different viewing perspectives may influence the perception of individual gaits or the qualities displayed through gait (e.g. emotion) by controlling the amount of relevant information available to the perceiver. The information that is important to identify a person (or an emotion) may be more easily seen from a frontal perspective or from a hybrid perspective (e.g. lateral torso sway). Therefore Jokisch et al. (2006) investigated the influence of viewpoint on the identification of person specific gait. They recorded walkers using motion capture equipment which then made the normalization of the walker’s body sizes possible. Therefore identification of particular walkers was based on walking kinematics and not on body structure cues. The synthetic walkers that will be created in the current research will also have the advantage of normalizing the body dimensions of the walkers shown to perceivers and thus the perception of specific emotions will be based on walking kinematics alone.
Jokisch et al. (2006) showed point-light walkers displayed from a sagittal, frontal and a 30° frontal perspective. The authors found that viewing perspective influenced the identification of other individuals but did not influence the perception of ones own walking patterns. The identification of other individuals walking style was significantly better from a frontal and a 30° frontal viewing perspective. The authors speculated that individuals have a natural disposition to attend to approaching individuals and thus have greater experience in perceiving different individuals from a frontal perspective. This explanation is congruent with the ecological perspective (Gibson, 1979/1986) that is being used in the current research. The current study also distinguishes the different emotions being studied through the circumplex model which encompasses the approach/withdrawal dimension. Therefore the perception of specific emotions in walking style is assumed to be optimal from the frontal viewing perspective. Walkers in each experiment of this research will therefore be displayed from the frontal perspective. Whilst it is not the aim of this research to verify this assumption, further research can be implemented to test the assumption made in the current research.

A common method used in all of the studies investigating the perception of individual specific walking styles is that the walker/perceivers were all familiar with each other. One can assume from this methodology and supported by their positive results that the walking style that is used to identify specific individuals are to a large extent constant. However, the emotional state of an individual is not constant. Emotions are responses to environmental stimuli and deplete quickly once that environmental stimuli is removed (Rottenberg et al. 2007). Therefore showing
walkers, who are familiar to perceivers, as they display specific emotions would provide minimal benefit to the current research. It has been argued through the ecological perspective that perceivers will be sensitive to the perception of specific emotions because of a historical adaptation and personal attunement of the perceptual system to perceive the emotional state of a walker (see sections 2.2.1.). Therefore the current research will not need the perceivers to have personal familiarity with the walkers shown in the experiments. The current research is therefore able to show perceivers a larger number of walkers displaying specific emotions which will dilute the possible influence of individualized walking styles on the perception of specific emotions.

In addition to perceivers having the ability to identify familiar individuals from their walking style, perceivers can also perceive victim potentiality of another person from their walking style. Winkel and McCormack (1997) found that people with a lack of interactional synchrony in their walking style were rated by perceivers as having lower self confidence and higher potential for robbery. Furthermore, the authors found that perceivers with higher criminal involvement rated walkers as more opportunistic to robbery thus providing some support for how Gibson’s (1979/1986) concept of affordances can influence an individual’s perception. Interactional synchrony was defined by the authors as the presence of a number of specific bodily movements during a gait cycle (e.g. single arm swing, walk stiffly). The authors instructed walkers as how to walk across a room as they were filmed. That is, the walkers would display a different number of interactionally synchronous gait movements on each recorded walk, thus the researchers could manipulate the degree of interactional synchrony that walkers displayed in their walking style. This
method for recording walkers would not suit the current research because it has not yet been established exactly how specific emotions are displayed through walking style. Therefore no valid instructions can be given to walkers about how to specifically display different emotions through their gait movements. It would thus be prudent to call upon the expertise of walkers who are trained and experienced in displaying specific emotions through their movement (i.e. actors). Therefore, in the current research actors will be instructed about which specific emotion they will be required to display through their walking style and then rely on their training/experience to accurately display emotion specific gait movements.

Furthermore, the methodologies created by Troje (2002) will be used in this research to statistically establish which gait movements are being used by perceivers to identify specific emotions. Researchers wishing to use Winkel and McCormack’s (1997) methodology may subsequently use the findings of the current research as a guide as to which instructions walkers should be given to display specific emotions through walking style.

Gunns et al. (2002) further differentiated between difficult-to-attack walkers and easy-to-attack walkers. Point-light walkers that were rated as difficult-to-attack were characterised as having a youthful gait embodied by fast long strides, full swing range of both arms and feet, with low levels of overall constraint in the body and high energy. In contrast, walkers that were rated as easy-to-attack were characterised by slow short strides, limited arm swing, lateral or forward/back weight shifts, and unenergetic constrained walking styles. Energised uninhibited movement appears to be perceived as an indication of a greater ability to either fight back or flee. A walker experiencing an approach emotion (e.g. anger) may therefore
display those emotions through energetic uninhibited movements. In contrast, a walker experiencing a negative withdrawal emotion (e.g. sadness or fear) may also be perceived as having the inability to fight back or flee. Gunns et al. (2002) also found that victim selection was based on the prediction of highest reward for lowest risk based solely on perception of gait kinematics. It is thus reasonable to assume that walkers that are perceived as having high reward and low risk for a potential attacker would also be experiencing a negative withdrawal emotion (i.e. sadness or fear). Walkers displaying sadness or fear may therefore embody some of the gait movements of an easy-to-attack walker. In contrast, a walker displaying anger may be more likely to fight back and thus increasing the risk associated with the reward. Therefore walkers displaying anger may embody some of the gait movements associated with a difficult-to-attack walker.

Furthermore, Johnston et al. (2004) attempted to teach women to change their walking kinematics to avoid future victimisation. Their success at lowering ease-to-attack ratings by altering walking kinematics was more effective than gait changes resulting from a self defence course. Whilst this finding does not apply directly to the theoretical or methodological discussions of the current research, it does suggest potential applications for the current research. Anti-victimisation programs can begin teaching individuals how to walk whilst displaying a potentially threatening emotion (i.e. anger) and thus ward off potential attackers. The current research may therefore inform the victimisation literature to the benefit of many.

Closer to the aims of the current study, Lemke et al. (2000) investigated the influence of clinical depression on walking style. Small brass plates with punched
out peaks (0.5mm) were attached to the soles of the shoes of the walkers as they walked across thin draft paper laid upon a soft carpet walkway. The punched out peaks would therefore leave tiny punctures in the draft paper where the walker stepped thus allowing stride length, step length, step width and foot angles to be calculated. Furthermore, timing lights were positioned 5m apart along the walkway to measure the pace of each walker. The walkers were recorded with a video camera so the different phases of their gait cycles could be analysed. Lemke et al. found that depressed walkers walked slower, had lower cadence, shorter stride length and had slower gait cycles than healthy control walkers. Lower cadence, shorter stride length and slower gait cycles all produce a slower walking pace (Kirtley, 2006) thus depressed walkers are found to walk slower than healthy controls.

However, the methodology used by the Lemke et al. (2000) has a limitation that is relevant to the current research. The draft paper that walkers walked on would have moved as the individual exercised the kinetic forces to translate their body weight down the predetermined path. That is, as the walkers propelled their bodies forward, they would have produced kinetic force pushing backwards (i.e. Newton’s third law of motion). The draft paper would therefore have likely slid backwards along the carpet as some of the kinetic force was diffused. Consequently the measurements of stride length, step length, step width and foot angles likely had some errors. Nevertheless both depressed walkers and healthy walkers were recorded under the same conditions and thus the study’s results should still be a valid representation of how walkers vary their walking style due to feelings of depression. However, recent advances in motion capture technology make the methodology used by Lemke et al. obsolete. Not only do motion capture systems
record gait movements with greater accuracy but they are also recorded in 3-dimensions (e.g. arm movements) and automatically synchronised with real time. Recording walkers with motion capture system is thus preferable in the current research than the gait recording techniques used by Lemke et al. (2000).

More recently, the expression of depression through walking gait has been investigated through modern motion capture methods (Michalak et al. 2009). Michalak et al. (2009) recorded 14 clinically depressed patients and contrasted their gait characteristics to 14 healthy (i.e. never been depressed) controls. A linear discriminant function was conducted by regressing the walker model parameters by the affiliated group (i.e. depressed vs. non-depressed). The resulting animations were visually compared to identify significant gait features that distinguished depressed and non-depressed individuals and were subsequently statistically compared. Depressed individuals were found to walk slower than non-depressed individuals therefore supporting the earlier findings by Lemke et al. (2000). Furthermore, depressed individuals showed reduced arm swing, greater lateral body sway, a more slumped posture and lower movement of the head.

Depression can be described as an intense form of sadness (Michalak, et al. 2009) and one of the aims of the current study is to investigate how sadness is perceived through walking style. Therefore the findings of Lemke et al. (2000) and Michalak et al. (2009) are likely to inform as to how sadness in particular will be displayed and thus perceived through walking style (e.g. slower pace). However, there are precious few studies that have investigated how different emotions are displayed through walking style. These studies will now be discussed in detail in
section 4.3. First, a particularly important variable (i.e. mode of walking) and how it may influence the current study will be discussed.

4.2. Treadmill vs. Locomotive Walking

The information that an individual expresses through their walking style is going to be influenced by the mode of walking that the individual is engaging in: treadmill walking or locomotive walking. Treadmill walking is when the individual is walking on a treadmill whilst locomotive walking is when the individual walks on the ground. Treadmill walkers and locomotive walkers exhibit quite distinct walking styles (Westhoff, 2005; White, Yack, Tucker, & Yin, 1998) even when the walker is the same person. Therefore any researcher investigating gait needs to make a very important choice about the type of gait being investigated. Both types of walking offer beneficial and detrimental consequences to the researcher which will consequently influence their resulting findings. This section will seek to explain why there are differences between the two types of walking and the advantages and disadvantages of using each type.

4.2.1. Biomechanical differences between treadmill walking and locomotive walking.

Locomotive walking is the type of walking that the average individual will engage in throughout their lives and can thus be termed normal unconstrained gait. On the other hand, treadmill walking imposes several biomechanical constraints upon the gait and thus the walking style is modified to deal with the constraints. Furthermore, perceivers appear sensitive to the biomechanical changes in treadmill walking compared to locomotive walking (Jokisch & Troje, 2003; Westhoff, 2005).
The first constraint that treadmill walking imposes is on the speed of the gait. The researcher can determine the pace of a walker by setting the treadmill to run at a predetermined speed. This may be desirable depending on the needs of the study but setting the predetermined pace may be occlude valuable information that the researcher may wish to investigate. In this research we are investigating the perception of different emotions through walking style but the perception of anger through walking style is clearly influenced by the velocity of the movements (Chouchourelou et al., 2006). Furthermore, the regulation of walking speed also restrains the walker from making subtle changes to their walking pace which may communicate the specific emotion that the walker may be displaying through their walking style (e.g. hesitant steps for fear). The control of a walkers speed would thus be detrimental for the present research.

However, the researcher may wish to let the walker choose the treadmill speed that they wish to walk on in an effort to eliminate the constraint that treadmill walking imposes on the speed of the gait (e.g. Troje, 2002). But doing so will not eliminate the biomechanical constraint on walking speed completely. First of all a treadmill constrains the step length of a walker through the size of the treadmill used in the research. A short treadmill will reduce the ability of a walker to take large steps. Walking speed is measured by the equation: step length x cadence, thus showing the relationship between step length and walking speed. Cadence is defined as the number of steps taken per minute (Kirtley, 2006). The relationship between step length, cadence and walking speed is even more evident in studies that compare male walkers to female walkers. Males generally have longer legs than females and
thus can take larger steps resulting in a faster walking pace even when males reduce their cadence (Sutherland, 1994). Since the gender of the walker is being investigated in the current research due to the possible influence it may impose on the perception of specific emotions, the control of step length may be detrimentally controlling important information for the perception of different emotions in walking style.

Nevertheless, any attempt by the researcher to use an oversized treadmill to compensate for the control of walker step length will have minimal effects. Walking involves an element of prediction in the same way that a long jumper modifies their step routine before hitting the take off mark and thus walking is influenced by the environment (Hommel et al. 2001). People tend to walk faster on a long runway (Murray, Kory, & Clarkson, 1966, 1969; Murray, Kory, & Sepic, 1970) because the walker can visually see the oncoming ground and can thus make step placement predictions well ahead of time. Consequently people tend to walk slower on a short runway (Oberg, Karszinia, & Oberg, 1993) because the walker is denied the required visual information to make step placement predictions at a fast pace and still be reasonably sure that they are walking safely. A treadmill walker, even on an oversized treadmill, will not be able to visually see the oncoming ground and thus will be more hesitant about making step placement predictions because the runway will always be short in comparison to the ground. The resulting gait on a treadmill will therefore be slower because the walker will take shorter steps due to walking on a visually short runway. This argument is congruent with Kirtly (2006) who found that, relative to locomotive walkers, treadmill walking adults stride length is 7% shorter and their cadence is 7% higher for a given walking speed which
consequently decreases the stance phase by 5%. Using a treadmill in the current research to record walkers gait movements would modify the walkers gait kinematics in a way that may negatively influence the perception of specific emotions through walking style.

Furthermore, treadmill walking modifies the kinetics underlying gait. Perceivers are sensitive to such gait modifications due to the information held within the kinematic cues of walkers, including point-light walkers (Jokisch & Troje, 2003; Runeson & Frykholm, 1981, 1983; Westhoff, 2005). Kinetics is defined as the spatial and temporal components of motion (e.g. velocity, acceleration) in relation to the forces that produce those movements (e.g. muscle strength, physiological energy systems), whereas the definition of kinematics makes no reference to the forces that produce the movements. Locomotive walking involves the actual translation of the individual’s body weight across space. Such translational movements require the muscles to exercise enough force in their muscle contractions to actually move the individual’s body weight outside of its base of support whilst still maintaining a balanced posture. In contrast a treadmill walker merely needs to make sure that their feet stay underneath them with their walking movements. They no longer need to propel the body forward (i.e. translate their body weight), thus requiring much less muscle force to walk (Yack, Tucker, & Collins, 1995). Thus even the energy requirements of treadmill gait differ from that of locomotive gait.

This section has shown that locomotive gait and treadmill gait differ in relation to their walking kinematics and kinetics and perceivers are sensitive to these changes. Researchers therefore need to weigh the advantages and disadvantages for
using both forms of gait in their research. The next section will seek to discuss some of these advantages and disadvantages and their relation to the current research.

4.2.2 The advantages of using locomotive walkers over treadmill walkers?

As previously stated, the choice to use treadmill walkers or locomotive walkers in a gait study is an extremely important choice. The choice will impact the type of research questions that can be answered, the design of the experiment and the interpretational validity of the results. This section will briefly highlight the benefits and detriments of using both treadmill and locomotive walking and justify our choice of using locomotive walking for the current research.

Treadmill walking is often used in gait research (Troje, 2002; Westhoff, 2005; Yamasaki et al. 1991) because treadmill gait can hold some very compelling benefits over locomotive walking. The first of which is that less space is required when using a treadmill. Until recently it has been very difficult for modern motion capture systems (e.g. Peak Motus, version 10) to record movements that transverse a large space. Walking is a locomotive activity which covers a large area, even with as little as a single complete stride. The limitation of space on the recording of gait movements thus required the walkers to remain stationary. The need to record full gait cycles, which fluctuate over time (Peng, Hausdorff & Goldberger, 1999), therefore necessitated the use of a treadmill in research using motion capture systems. However, recent advancements in motion capture systems have produced more accurate recordings in much larger capture volumes (e.g. Vicon Nexus, version 1.1, Oxford Metrics Limited). The traditional limitation of small capture volume for the recording of gait movements no longer requires the use of a treadmill.
Locomotive walkers can therefore be recorded thus increasing the ecological validity of the gait movements used in the research.

A second advantage of using a treadmill in gait research is that the speed of the walker can be controlled. Whilst this is an advantage to any researcher that directly wishes to control the speed of a walker, it can prove disadvantageous to any researcher for which walking pace may be a vital component to the question they wish to investigate. For example in the current research walking pace may be a vital cue to the identification of specific emotions through gait movements. Energetic emotions, such as anger, produce a faster walking pace than lethargic emotions, such as sadness (Darwin, 1872, 1999; Edgeworth, Keen, Crane & Gross, 2008; Montepare et al., 1987; Troje, http://www.biomotionlab.ca/Demos/BMLwalker.html). Controlling the pace of walkers would therefore be detrimental to the current study.

A third advantage of using a treadmill is that the safety of the walker can be improved through the use of a harness of handrails. This can very advantageous for studies investigating pathological gaits (e.g. spasticity). However, in the current study we are using walkers with no physical impairment to their gait and thus are assumed to be so practiced at walking that they can be described as gait experts. An expert walker would therefore not be in danger of hurting themselves when walking across a flat unobstructed floor. Using a harness or handrails would thus provide no benefit to the current study.
In fact the use of a harness or handrails would prove detrimental to the current study by disturbing the ecological validity of the walking style. A walker whose weight is supported by a harness or handrails will have a very different walking style because they will have changed the kinetics required to walk. As discussed previously a change in the kinetics of walking alters the kinematics of walkers which is thus perceivable to perceivers (Jokisch & Troje, 2003; Runeson & Frykholm, 1981, 1983; Westhoff, 2005). The consequent walkers will therefore lack ecological validity.

The ecological theory of visual perception (Gibson, 1979/1986) argues that in order for our perceptual systems to adapt and attune to perceive important stimuli we need to be exposed to the stimuli. Therefore the ecological validity is of critical importance to the current study. As has been previously argued treadmill walkers have decreased ecological validity due to the modifications to the kinetics and kinematics of their walking style. In contrast, locomotive gait has more ecological validity than treadmill gait, because locomotive gait is the form of walking used everyday to transverse our immediate environment. Perceivers will thus be most sensitive to perceiving gait movements that are representative of the same gait movements previously seen in the ecological environment. The perception of different emotions through walking style would therefore be improved when using locomotive walkers as opposed to treadmill walkers.

What has become apparent in this section is that there are different methods for conducting gait research. Many more methods become possible when researchers start investigating the display or the perception of various psychological states or
character attributes through gait. However, few studies have actually investigated
the perception of specific emotions through gait. These studies will now be
discussed in detail.

4.3. Perception of Emotion through Walking Style

There have been a couple of studies investigating whether different emotions
can be perceived through walking style (Chouchourelou et al. 2006; Heberlein et al.
2004). However, few studies have directly investigated how different emotions
(specifically happiness, sadness or anger) are expressed through walking style
(Montepare et al. 1987; Michalak et al. 2009). These papers will therefore be
discussed in depth.

Montepare et al. (1987) found that perceivers could accurately identify four
emotions (happy, sad, anger, and pride) in walking style above chance levels. The
authors recorded five female walkers as they imagined themselves in an emotion
congruent scenario. The walkers were dressed in similar comfortable clothing (i.e.
jeans and a sweatshirt). The authors then showed black and white video recordings
of the walkers (from the neck down) to 10 female perceivers. The authors described
to perceivers the scenarios and the congruent emotion that each walker was walking
in. Perceivers saw the sequence of walkers twice. The first time they were required
to identify the emotion that the walker was feeling. The second time the perceivers
were required to rate the walkers on four walking characteristics: stride length (short
or long), amount of arm swing (none or a lot), the degree of postural slouching
(slouching or up straight) and how light/heavy the walkers footsteps were.
Montepare et al. (1987) found: a) Happy walks were characterised by a faster pace. Despite this claim only 3 out of 10 perceivers reported perceiving happy walks as faster. b) An angry walk was characterised by more arm swing, heavier footsteps and a longer stride. c) A sad walk was characterised by significantly less arm swing and was correctly identified the best out of the four emotions. d) Pride was also characterised by a longer stride but was often confused with anger. Pride was not identified as well as the other emotions. From an ecological perspective certain emotions will be more effectively perceived than other emotions because of their respective adaptive value (McArthur & Baron, 1983). For example, anger would signal danger to the perceiver whilst pride would not afford the perception of any threat to the perceiver’s survival. However, this argument does not explain why sadness was correctly identified the best out of the emotions. Montepare et al. made no attempt at explaining why sadness was identified better than the other emotions.

However, the study by Montepare et al. (1987) suffers from an important methodological shortcoming: their procedure does not allow identifying potential confounding factors and therefore cannot prevent them from influencing the results. The use of an imagination method of priming the walkers with the different emotions is problematic. Westermann et al. (1996) found through meta-analysis that the imagination method of priming emotions was only suitable for priming negative emotions and only the 6th best emotion priming method overall. It can thus be assumed that some of the walkers failed to be successfully primed of the intended emotion, especially for the positive emotions (e.g. happiness and pride). The small sample of walkers (5 walkers) used by Montepare et al. (1987) in the construction of their walking stimuli exaggerates this problem. Unlike the ability of actors to validly
express emotions despite the absence of the felt experience of that emotion, the
ability of emotion primed individuals is contingent on the success of the priming.
The authors failed to verify the success of their priming procedure and thus the
results of their study must be interpreted with caution.

Furthermore, each individual has a specific method of moving which varies
considerably from other individuals, especially for displaying different emotions
(Wallbott & Scherer, 1986). Montepare et al. even realised the problem and
acknowledged that the ratings for the ‘heavyfootedness’ variable were the same
across the emotion conditions for each walker and thus were likely to be due to
individual walking style differences and not due to the nature of specific emotions.
However, the authors still considered it justified to attribute even slight difference
across the emotion conditions to be representative of the specific emotions and
ignored the possible contribution of individualised walking styles. It is doubtful that
5 walkers can show enough consistency in their kinematics for perceivers to derive
emotion specific information whilst still correcting for differences in individual
walking styles. Perceived movements that are characteristic of that particular
individual walker may therefore be confused with emotion specific kinematic
information, especially when considering the demand characteristics of the task (i.e.
looking for emotion in walking style, Walk & Homan, 1984). However, ecological
theory (Gibson, 1979/1986) would disagree and argue that humans, as a species,
have long adapted their perceptual systems to perceive specific emotions through
walking style regardless of individual walking differences. Nevertheless, the small
sample of walkers is statistically susceptible to a larger extent to the influence of
confounding factors such as unsuccessful priming and individual walking styles
(Cohen, 1992). For example, despite the increased likelihood that happy walkers failed to be successfully primed of happiness and that only 3 out of 10 perceivers saw happy walkers as walking faster the authors concluded that happy walkers walk faster. The use of a larger sample size in the creation of walker stimuli would limit this problem. Common movement patterns amongst walkers will be statistically separated from individual specific gait movements with greater confidence. A larger sample size will therefore be used in this study.

Additionally, all the walkers used by Montepare et al. (1987) were female. Numerous studies have found that there are significant gender differences in walking style (Gunn et al. 2002; Schmitt & Atzwanger, 1995; Troje, 2002; Yamasaki et al. 1991). The findings of Montepare et al. can therefore only be generalised to the female population. This research will therefore be comparing males to females in all aspects of this study.

There is another example of research investigating how different emotions are perceived through walking style. Troje and colleagues show on their website (http://www.biomotionlab.ca/Demos/BMLwalker.html) an example of how point-light walkers change their walking kinematics depending on if they are sad or happy. Happy walkers are characterised by a faster bouncier gait, whilst sad walkers are characterised by a slower slouching gait. The exemplar happy and sad walkers support the findings of Montepare et al. (1987). The website claims the same methodologies Troje (2002) used in his work on gender identification in walkers, was also used to create these exemplars of happy and sad walkers. No paper has yet been published on the utility of these methods for determining the effect of different
emotions on walking style. Therefore no solid critique of the study can be made regarding these findings. Troje’s (2002) methods (described in detail in section 9.2.), however appears to be very suitable for emotional gait analysis and will therefore be used in this research to verify whether they are suitable for determining how different emotions are perceived through walking style.

More recently, Michalak et al. (2009) investigated how sadness was displayed through walking gait relative to happy individuals. Sad walkers, relative to happy walkers, were found to walk slower, display reduced arm swing, greater lateral sway, a more slumped posture and reduced vertical movement of the head. Happiness and sadness was primed in the walkers through a music mood induction procedure. However, Westermann et al. (1996) found through meta-analysis that music mood induction was a valid method for inducing negative moods but not positive moods. This may be why Michalak et al. (2009) found no significant difference in the self reported affect ratings of the participant walkers after the experiment preparation (i.e. changing of clothes, placement of markers) and after positive mood induction. However, the process of the experiment preparation seemed to have positive mood inducing effect as the walkers reported affect ratings increased significantly from before the experiment to after the experiment preparation. It thus appears that Michalak et al. (2009) unintentionally induced positive mood in the walkers by the novel motion capture experience but this positive mood was counter-primed through a successful music mood induction method. Therefore the findings of Michalak et al. (2009) are likely valid depictions of happy and sad walking characteristics and are further supported by the
prototypical happy and sad walkers exhibited on the website of Troje and colleagues (http://www.biomotionlab.ca/Demos/BMLwalker.html).

However, the research conducted by Michalak et al. (2009) does not identify whether the identified gait differences are significantly different from a non-emotional walk (i.e. neutral emotion). Therefore these identified gait differences may be characteristic of a non-emotional walker changing their walking style towards sadness or towards happiness or both. Without a neutral emotion baseline, we can not distinguish between a neutral walk and a happy or sad walking style. Therefore in this research we will record and display neutral emotion walkers to perceivers. Furthermore, Michalak et al. (2009) attempted to draw conclusions about the expression of negative moods in general through walking gait despite acknowledging that this may not be the case. Anger and fear, due to their inherent action orientated purpose (Gibson, 1979/1986; Walk & Homan, 1984), are likely to be expressed, and therefore perceived, through different gait characteristics (Montepare et al. 1987). Therefore in this research we will also include the basic emotions anger and fear in our analysis of the perception of specific emotions through walking style.
Chapter 5

Rationale for Research

Throughout this research, emotions that are theoretically opposed in the proposed circumplex model (see Figure 3.1) will be compared in relation to the baseline of neutral (Davidson et al., 1990). Happiness will be contrasted to sadness. Both emotions represent opposite ends of both the hedonics and the approach/withdrawal dimensions. Happiness is a positive approach emotion whilst sadness is a negative withdrawal emotion. Additionally, anger will be contrasted to fear. Both anger and fear are considered negative emotions but they differ on the approach/withdrawal dimension. Anger is an approach emotion whilst fear is a withdrawal emotion. The neutral emotion is considered a comparison for the other emotions because it sits at the centre of both dimensions for discriminating different emotions.

The aim of the present research is to investigate if specific emotions can be perceived through the kinematics of walking style. This research will seek to answer the following main research question: Can different emotions be reliably perceived through the kinematics of gait? Subsidiary research questions will be used to answer the main research question by investigating possible influences on the perception of emotion through another’s walking style. The main research question will be addressed in three subsidiary research questions: 1) Can perceivers reliably identify the emotion that a walker is displaying through their walking style? 2) Is the alarm hypothesis supported when perceiving different emotions through walking style? 3) Does the gender of the walker influence the perception of different emotions through
their walking style? These research questions (abbreviated in Table 5.1.) will be investigated for the perception of specific emotions through walking style as shown through: a) full-light walkers (experiment 1), b) point-light walkers (experiment 2) and c) synthetic point-light walkers (experiment 3).

Each research question investigated in the first three experiments will be addressed through specific hypotheses (abbreviated in Table 5.2.). Each of the research questions will be revisited here and the pertinent hypotheses summarised and justified. The first research question is testing whether perceivers can reliably identify the emotion that a walker is displaying through their walking style. Ecological theory (Gibson, 1979/1986) argues that perception is largely veridical thus it is predicted that not only will perceivers reliably identify specific emotions in walking style but the identified emotion will be congruent with the emotion displayed by the walker.

The second research question is testing whether the alarm hypothesis is supported when perceiving different emotions through walking style. The alarm hypothesis states that humans perceive emotions through body movement better and more easily if those emotions are important for survival (Dittrich et al. 1996; Walk & Homan, 1984). For example, anger may be perceived the easiest of all emotions because an angry person may attack. These same emotions should need less emotion-related information in a person’s walking style to allow a viewer to accurately perceive the felt emotion of the walker. The alarm hypothesis directly tests the relevance of the approach/withdrawal dimension of distinguishing emotions derived from ecological theory (Gibson, 1979/1986), especially when considering
that walking is generally the method used to approach or withdraw from an individual. It is therefore predicted that perceivers will be able to accurately perceive a lower intensity of anger in full-light walkers than for all other emotions (i.e. happiness, sadness, and fear). It is also predicted that perceivers will be able to accurately perceive fear at a lower intensity than either happiness or sadness. Both of these predictions are based on the findings of Walk and Homan (1984) who found that anger followed by fear were the only emotions that were identified through point-light displays of various full body movements (including walking) when the perceivers were instructed to “describe what they saw on each trial” (p438).

However, walking is a method to either approach or withdraw from another perceived individual. Individuals displaying approaching emotion-laden behaviours (i.e. happiness and anger) are going to advance on the perceiver faster than an individual displaying withdrawing emotion-laden behaviour (i.e. sadness and fear). Consequently, approach emotions need to be perceived quicker than withdrawal emotions because the perceiver has less time to decide on an appropriate reactive behaviour. It is therefore also predicted that happiness and anger will be identified faster than sadness and fear in both male and female walkers.

Due to the adapting and attuning of the perceptual systems to emotions that are relatively important to survival (Gibson, 1979/1986), the perception of that emotion is assumed to occur more rapidly than perception of emotions that are less relevant to survival. This assumption is supported by Vaughn Becker et al. (2007) who found that angry male faces and happy female faces were identified faster than happy male
Table 5.1

*Summery of the Independent Variables, Dependent Variables and Research Questions Pertinent to each Experiment*

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Stimuli</th>
<th>IV’s</th>
<th>DV’s a</th>
<th>Research Questions a,b</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Full-light Walkers</td>
<td>Displayed Emotion</td>
<td>Perceived Emotion</td>
<td>ID emotion: high inter-rater agreement?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Displayed Intensity &amp; Walker Gender</td>
<td>ID Ratings &amp; ID Times</td>
<td>ID displayed emotion?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alarm Hypothesis supported?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gender influences on emotion perception?</td>
</tr>
<tr>
<td>2</td>
<td>Point-light Walkers</td>
<td>Displayed Emotion</td>
<td>Perceived Emotion</td>
<td>ID emotion: high inter-rater agreement?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Displayed Intensity &amp; Walker Gender</td>
<td>ID Ratings &amp; ID Times</td>
<td>ID displayed emotion?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alarm Hypothesis supported?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gender influences on emotion perception?</td>
</tr>
<tr>
<td>3</td>
<td>Synthetic Walkers</td>
<td>Displayed Emotion</td>
<td>Perceived Emotion</td>
<td>ID emotion: high inter-rater agreement?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Displayed Intensity &amp; Walker Gender</td>
<td>ID Ratings &amp; ID Times</td>
<td>ID displayed emotion?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alarm Hypothesis supported?</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gender influences on emotion perception?</td>
</tr>
<tr>
<td>4a &amp; 4b</td>
<td>Synthetic Walkers, Visual Noise</td>
<td>Adapting Stimulus</td>
<td>Perceived Emotion</td>
<td>Adaptation aftereffects for emotion perception?</td>
</tr>
<tr>
<td></td>
<td>(4a only)</td>
<td>&amp; Target Emotion</td>
<td>ID Ratings &amp; ID Times</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Synthetic Walkers</td>
<td>Adapting Emotion</td>
<td>Perceived Emotion</td>
<td>Neural Fatigue vs. Adaptation Theory?</td>
</tr>
<tr>
<td></td>
<td>&amp; Target Emotion</td>
<td></td>
<td>ID Ratings &amp; ID Times</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* The research questions are abbreviated from more lengthy descriptions in the text.

aID is an abbreviation for identification. bAny expression preceding ‘:’ pertains to a specific condition applicable to that hypothesis.
faces and angry female faces (see section 3.5.2. for further details). This finding is congruent with the affordances that males and females displayed through their facial expressions (Taylor et al. 2000; Trivers, 1985). It is therefore predicted that anger will be identified faster than all the other emotions (i.e. happiness, sad and fear). However, De Sonneville et al. (2002) and Eastwood et al. (2003) found that perceivers take longer to count negatively valenced faces in a crowd compared to positively valenced faces. De Sonneville et al. (2002) and Eastwood et al. (2003) argue that the conscious perception of an emotion that is critical to the perceiver’s survival is delayed in favour of acting on that perceived emotion (e.g. fight-or-flight). Therefore, the opposite prediction is also made that anger will be identified slower than all the other emotions.

Despite the evidence for speed of emotion perception being based on facial expressions, which is thought to utilise distinct brain systems (Buccino et al., 2001), the three studies (De Sonneville et al. 2002; Eastwood et al. 2003; Vaughn Becker, et al. 2007) base their arguments on the type of emotions being perceived and not on display format specific processes (i.e. facial expressions). It can be reasonably assumed that the results from Vaughn Becker, et al. (2007), De Sonneville et al. (2002) and Eastwood et al. (2003) generalise to the perception of different emotions through walking style. It can therefore also be argued that happy walkers will be identified faster than all other emotions.

The third research question is testing whether the gender of the walker influences the perception of different emotions through walking style. Males and females have gender specific walking kinematics (Gunn et al., 2002; Schmitt &
Atzwanger, 1995; Troje, 2002; Yamasaki et al., 1991) and Montepare et al.’s (1987) results can only be generalised to females. Furthermore, males, who are generally seen as the more aggressive gender (Antill, 1987; Mussweiler & Forster, 2000), may be more likely to be perceived as feeling an approach emotion (i.e. happiness and anger). Females, on the other hand, who are generally perceived as the more passive gender (Zammuner, 1987), may be more likely to be perceived as feeling a withdrawal emotion (i.e. sadness and fear). Based on this reasoning it can therefore be predicted that male walkers will be generally perceived as expressing significantly more approach emotions (i.e. anger, happy) compared to withdrawal emotions (i.e. sad, fear). Alternatively, female walkers are predicted to be generally perceived as expressing significantly more withdrawal emotions than approach emotions.

Furthermore, the gender of the walker likely influences the application of the alarm hypothesis (Walk & Homan, 1984) to the present research. Perceivers, due to the relative importance for survival, have likely adapted and attuned a perceptual bias towards anger in males because an angry male is more dangerous than an angry female (Antill, 1987; Mussweiler & Forster, 2000). Therefore it is predicted that anger will be identified faster and at a lower level of displayed intensity in male walkers than in female walkers. Similarly, perceivers have likely developed a perceptual bias towards fear in females because in times of threatened survival, the passive behaviour associated with the female gender (Zammuner, 1987), is most likely to be interpreted by a perceiver as fear. Therefore it is also predicted that fear will be identified faster and at a lower level of displayed intensity in female walkers than in male walkers.
However, Vaughn Becker, at el. (2007) found a perceptual bias towards anger on male faces and towards happiness on female faces. Therefore alternative predictions are also made that angry male walkers and happy female walkers will be identified significantly more than any other emotion for either walker gender.

In summary, conflicting theoretical arguments give rise to hypotheses that directly compete with alternative hypotheses. These specific hypotheses (abbreviated in Table 5.2) are collectively described here and will be tested in the first three experiments with full-light (experiment 1), point-light (experiment 2) and synthetic walkers (experiment 3): 1) Perceivers will reliably identify above chance the specific emotion that a walker is displaying through their walking style. 2) Male full-light walkers will be perceived as displaying significantly more approach emotions (i.e. happiness and anger) than withdrawal emotions (i.e. sadness and fear). 3) Female full-light walkers will be perceived as displaying significantly more withdrawal emotions (i.e. sadness and fear) than approach emotions (i.e. happiness and anger). 4) Male full-light walkers displaying anger will be identified significantly more than any other emotion displayed by male walkers. 5) Full-light walkers displaying anger will be identified by perceivers significantly more when the walker is male than when the walker is female. 6) Female full-light walkers displaying happiness will be identified significantly more than any other emotion displayed by female walkers. 7) Full-light walkers displaying happiness will be identified by perceivers significantly more when the walker is female than when the walker is male. 8) Perceivers will be able to accurately identify a lower intensity of displayed anger in full-light walkers than for all other emotions. 9) Perceivers will
be able to accurately identify a lower intensity of displayed fear in full-light walkers than either happiness or sadness. 10) Perceivers will rate correctly identified angry full-light walkers as expressing a significantly lower level of intensity when the walker is male as compared to female. 11) Perceivers will rate correctly identified fearful full-light walkers as expressing a significantly lower level of intensity when the walker is female as compared to male. 12) Happiness displayed through walking style will be identified significantly faster than all other emotions. 13) Anger will be identified significantly faster than all other emotions. 14) Anger will be identified significantly faster in male walkers than female walkers. 15) Fear will be identified significantly faster in female walkers than male walkers. 16) Negative emotions will be identified significantly slower than positive emotions. 17) Anger will be identified significantly slower than all other emotions.

An additional aim of this research is to create a set of stimuli that reliably show the gait movements associated with different emotions (i.e. synthetic walkers, see section 9.2. for details). The synthetic walkers will then be used in subsequent experiments investigating the influence of adaptation aftereffects on the perception of emotion through walking style. The synthetic walkers will be created from the identifications from experiment 2 (i.e. point-light display walkers) and the techniques outlined by Troje (2002). The research questions investigated with both full-light and point-light walkers will subsequently be investigated with the synthetic walkers. The created synthetic walkers will be artificially manipulated to exaggerate the movement cues that are used by perceivers to identify different emotions in walking style, thereby informing as to the walking movements that communicate specific emotions to perceivers.
### Table 5.2

*Abbreviations for Each Hypothesis Tested in the Full-light, Point-light and Synthetic Walker Experiments*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis$^{a,b}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification Rates</td>
<td>Emotion &gt; Chance</td>
</tr>
<tr>
<td></td>
<td>Male: Happy and Anger &gt; Sad and Fear</td>
</tr>
<tr>
<td></td>
<td>Female: Sad and Fear &gt; Happy and Anger</td>
</tr>
<tr>
<td></td>
<td>Male: Anger &gt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Male Anger &gt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female: Happy &gt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Female Happy &gt; Male Happy</td>
</tr>
<tr>
<td>Identified Emotion</td>
<td>Anger &lt; All other Emotions</td>
</tr>
<tr>
<td>Identified Times</td>
<td>Fear &lt; Happy and Sad</td>
</tr>
<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td></td>
<td>Happy &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Anger &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td></td>
<td>Happy and Anger &lt; Sad and Fear</td>
</tr>
<tr>
<td></td>
<td>Anger &gt; All other Emotions</td>
</tr>
</tbody>
</table>

*Note. Some of these hypotheses may appear contradictory because they are derived from opposing arguments or evidence.  
$^a$</>$^b$ denotes the direction of the specific hypothesis.  
$^b$Any expression preceding ‘:’ pertains to a specific condition applicable to that hypothesis.*

Once the successful display of each emotion by the synthetic walkers has been verified, the synthetic walkers will act as stimuli in the following three experiments aimed to investigate the influence of adaptation aftereffects on the perception of specific emotions in walking gait. This additional research aim will be answered by
two subsequent research questions: 5) Do adaptation aftereffects influence the perception of specific emotions through walking style? This research question will be addressed in experiments 4a and 4b. 6) Does the neural fatigue theory or the adaptation theory of adaptation aftereffects best explain the existence (if any) of adaptation aftereffects in the perception of specific emotions through walking style? This research question will be addressed in experiment 5. By answering these additional research questions (abbreviated in Table 5.1), we can obtain a clearer understanding of the perception based results in experiment 1 (full-light walkers), 2 (point-light walkers), and 3 (synthetic point-light walkers).

Each of the adaptation aftereffect related research questions will be investigated through specific hypotheses (abbreviated in Table 5.3). The aim of experiment 4a will be to verify that a neutral walker does not produce aftereffects in the perception of subsequently shown walkers displaying different emotions (i.e. happiness, sadness, anger & fear). Thus it is predicted that, compared to a screen of visual noise, a neutral walker will not produce significantly different identification rates, perceived intensity ratings and identification times for the subsequently shown emotion displaying walkers. If these hypotheses are supported then the neutral walker can be used as a baseline to which each other investigated aftereffect can be statistically compared in experiment 4b.

Experiment 4b will directly test if adaptation aftereffects influence the perception of subsequently displayed emotions in walkers. However, there are two different types of aftereffects: inhibition aftereffects and facilitation aftereffects.
Table 5.3

Abbreviations for Each Hypothesis Tested in the Adaptation Aftereffect Experiments

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Dependent Variable&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Hypothesis&lt;sup&gt;b,c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a</td>
<td>ID Rates</td>
<td>All Emotions: Adapting Neutral = Adapting Visual Noise</td>
</tr>
<tr>
<td>ID Intensity Ratings</td>
<td></td>
<td>All Emotions: Adapting Neutral = Adapting Visual Noise</td>
</tr>
<tr>
<td>ID Times</td>
<td></td>
<td>All Emotions: Adapting Neutral = Adapting Visual Noise</td>
</tr>
<tr>
<td>4b</td>
<td>ID Rates</td>
<td>Happiness: Adapting Happy &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td>ID Intensity Ratings</td>
<td></td>
<td>Happiness: Adapting Sad &gt; Adapting Neutral Walker</td>
</tr>
<tr>
<td>ID Times</td>
<td></td>
<td>Sadness: Adapting Sad &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sadness: Adapting Happy &gt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anger: Adapting Angry &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anger: Adapting Fear &gt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fear: Adapting Fear &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fear: Adapting Anger &gt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td>ID Intensity Ratings</td>
<td>Happiness: Adapting Happy &gt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td>ID Times</td>
<td>Happiness: Adapting Sad &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sadness: Adapting Sad &gt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sadness: Adapting Happy &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anger: Adapting Angry &gt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Anger: Adapting Fear &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fear: Adapting Fear &lt; Adapting Neutral Walker</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fear: Adapting Anger &lt; Adapting Neutral Walker</td>
</tr>
</tbody>
</table>

Note. The hypotheses for experiment 5 will seek to confirm the supported hypotheses from experiment 4b but with a longer inter-stimulus duration.

<sup>a</sup>ID is an abbreviation for identification.
<sup>b</sup>=<</> denotes the direction of the specific hypothesis.
<sup>c</sup>Any expression preceding ‘:’ pertains to the specific identified emotion applicable to that hypothesis.
Inhibition aftereffects decrease the perception of stimuli after adapting to similar stimuli (Hsu & Young, 2004). It is thus predicted that perceivers will identify each displayed emotion less and in more time after viewing a walker showing the same emotion than after viewing a neutral walker. Similarly, it is predicted that perceivers will require more displayed emotional information before being able to identify the displayed emotion thus they will rate each identified emotion as more intense after viewing a walker displaying the same emotion than after viewing a neutral walker.

Facilitation aftereffects, on the other hand, increase the perception of stimuli after adapting to opposing stimuli (Hsu & Young, 2004). However, the oppositional nature of different perceived emotions is not clear. Nevertheless, Hsu and Young (2004) found a facilitation effect between the perception of facial displays of happiness and sadness thus supporting the argument that the perception of happiness and sadness are categorically opposite. Happiness is therefore predicted to be identified more, faster and with less intensity after adapting to a sad walker than after adapting to neutral walker. Likewise, sadness is also predicted to be identified more, faster and with less intensity after adapting to a happy walker than after adapting to neutral walker. Correspondingly, the fight-or-flight response (Trivers, 1985) considers anger and fear as perceptually and behaviourally opposite. The ecological theory of social perception (McArthur & Baron, 1983) is largely congruent with the fight-or-flight response (Trivers, 1983) thus supporting the perceptually opposite categorisation of anger and fear. Therefore, anger is predicted to be identified more, faster and with less intensity after adapting to a fearful walker.
than after adapting to neutral walker. Likewise, fear is also predicted to be identified
more, faster and with less intensity after adapting to an angry walker than after
adapting to neutral walker.

In order for each of these research questions/hypotheses to be validly tested we
need to construct a set of walker stimuli that sufficiently display each emotion. The
next chapter therefore will discuss the construction of the walker stimuli that will be
shown to perceivers in the first two experiments (i.e. full-light walkers & point-light
walkers). Furthermore, we will justify our choices regarding the chosen
methodologies for creating our emotional walker stimuli.
Chapter 6

Stimulus Construction - Recording of Walkers Expressing Specific Emotions

6.1. Introduction

This research will be looking at how different emotions are perceived through walking style. It is therefore imperative for the following experiments that a set of walkers are recorded that satisfactorily display different emotions through their walking style. There are at least three ways to do this: 1) Record people walking without any instruction and then let the perceivers discriminate the different emotions through their walking style. 2) Prime different emotions in the walkers so the walkers actually feel the emotions they are intending to express. 3) Hire actors who are trained at expressing different emotions through their movement to display different emotions through their walking style. Each method has advantages and disadvantages that will be discussed in the remainder of this section.

The first potential method of recording walkers is to record the kinematics of a number of different people walking with no instruction regarding how to express different emotions. That is the participants are told to walk naturally and then perceivers of the walkers will categorise and rate the walkers on the degree to which each emotion is expressed. It is assumed that this method was used for the creation of the prototype happy and sad walkers that are displayed on Troje and colleague’s website (http://www.biomotionlab.ca/Demos/BMLwalker.html). Since Troje has published no paper regarding the expression of sadness or happiness through gait
motion, the specifics of the methodology used can not be attested for. Nevertheless
the assumption can be made based on another page of the same website
(http://www.biomotionlab.ca/Demos/BMLrating.html) where any visitor can enter
an axis they are interested in (e.g. confidence). The user is then asked to rate a set of
point-light walkers according to their axis of interest. Finally the same methodology
is applied that was used by Troje (2002) to generate a slider that can modify the
point-light walkers kinematics from one extreme (e.g. high confidence) to the
opposite extreme (e.g. low confidence) on their desired axis (i.e. confidence). There
is no requirement on the part of the point-light walkers displayed to actually embody
any of the attribute that the user is interested in. This is problematic from an
ecological perspective (Gibson, 1979/1986); when there is no emotion displayed
through the walking movements then a perceiver can not perceive the emotion.
However, natural variability in walker’s movements may produce walking styles
that resemble gaits that are characteristic of specific emotion expression. Troje’s
(2002) statistical methods for creating the kinematic walker exemplars segregate the
movements of various walkers according to the perceiver ratings that they received,
regardless of any intended expression of the rated attribute on the part of recorded
walker.

A drawback to using Troje’s (2002) methodology for creating walkers that
express specific emotions is that perceivers would find it more difficult to categorize
and rate a set of point-light walkers that were not expressing the attribute that the
perceivers were attempting to respond to. The subsequent experimental data would
therefore have more noise than desired; that is the gait kinematics for different
emotions would be confused with each other to a larger degree. Furthermore,
confounding factors can potentially influence the results to a larger degree. For example, the gender of the walker may influence the perception of specific emotions more than usual due to a lack of any emotion specific information on which perception based ratings can be made (e.g. male walkers rated as angrier than female walkers). The experimental data would therefore bias the results against the proposed hypotheses of this research.

The first potential method of recording walkers was therefore not adopted for this research because it was felt it was important to tease apart further the movements that are used by perceivers to identify different emotions. The walkers should thus display the specific emotions that perceivers are attempting to perceive. However, Troje’s techniques for creating walker exemplars for the expression of specific emotions will be created from the perceiver ratings from experiment 2 and tested in experiment 3 (see section 9.2).

The second potential method for recording walkers is to prime the walkers with the specific emotions being investigated in this research. This method is attractive because the walkers would actually feel the emotion that they are intending to express. Many studies investigating emotion perception use perceptual data (i.e. ratings, correct categorizations) to infer to the actual method of expressing specific felt emotions (Atkinson et al. 2004; Dittrich et al. 1996; Pollick et al. 2001). However, there may be incongruence between individuals’ perception of specific emotions and their methods of expression for specific emotions due to the influence of other confounding factors (e.g. perceiver’s affordances, walker gender). Therefore recoding walkers who actually feel the emotions they are intending to express
permits stronger conclusions to be made regarding how different emotions are actually expressed through walking style, as opposed to how they are assumed to be expressed based on perceptual data.

The priming method has some methodological pitfalls though. Emotion is a response to environmental stimuli (Rottenberg et al. 2007), therefore in order to prime specific emotions stimuli must be presented to the walkers that can effectively prime the intended emotional response (known as Mood Induction Procedures: MIP). A variety of MIP’s are available for priming different emotions (music, Pignstielo, Camp, & Rasar, 1986; film/story, Rottenberg et al. 2007; Philippot, 1993; imagination, Brewer, Doughtie & Lubin, 1980; Schwarz & Clore, 1983; self-referential statements, Velten, 1968; facial expression, Leventhal, 1980; or combination of different emotion priming methods). Westermann, Spies, Stahl and Hesse (1996) conducted a meta-analysis comparing the different MIP’s in relation to their effectiveness on successfully priming the intended emotion. They found that the film/story MIP was the most effective for inducing both positive and negative emotions. Rottenberg, et al. (in press) has since created a library of films that successfully primes the feeling of specific emotions (e.g. amusement, fear, anger, neutral and sadness). The use of an emotion priming film library introduces another limitation of using the priming method: time.

Emotional responses occur over a time period of seconds yet the relevant emotion priming films (Rottenberg et al. 2007) for this study run from 1.22 min (fear) to 7.59 min (amusement). It is difficult to say when the emotion is actually felt by the viewer and when the felt emotion ceases. This difficulty is important
regarding the recording of emotionally primed walkers because walking is a locomotive movement. In order for the walkers to continually view the emotion priming film the film either has to travel with the walker or the walker must be stationary (i.e. on a treadmill). As discussed previously (section 4.2.1.) treadmill walking differs from locomotive walking due to several biomechanical restraints imposed by the treadmill (Westhoff, 2005). Furthermore, the success of the emotional priming needs to be verified (e.g. self-rating task). Due to the relative short life of the felt emotion compared to the longer duration of the priming films (Rottenberg et al. 2007) it is difficult to isolate the most advantageous time to record the walking movements and subsequently verify the success of the emotional priming.

Montepare, et al. (1987) primed specific emotions in their walkers by asking them to imagine themselves in one of four emotional scenarios that were provided by the researchers. The authors chosen method of priming emotion is only effective for negative emotions (Westermann et al. 1996) therefore the priming of specific emotions might have failed on some of the walkers, especially for happy and proud walkers. Furthermore, Montepare, et al. (1987) did not test whether their procedure for priming specific emotions actually primed the intended emotions. Therefore the perception data for the walkers who were unsuccessfully primed with emotion would be confused with the walkers who were successfully primed with emotion. The resulting interpretation of Montepare, et al.’s (1987) results is therefore weakened because the success of the emotional priming, which is a major assumption of the study, was not verified.
The advantage of using walkers primed of emotion is that stronger conclusions can be made about how specific emotions are expressed through walking style. However, the priming method was not chosen for this research because the difficulties in priming specific felt emotions (in relation to locomotive movements) and then verifying that the intentionally primed emotions were actually being felt by the walkers at the time of the recording.

The third potential method of recording walkers expressing different emotions is to hire actors who have been trained to express specific emotions through their movements. The actor method rests on the assumption that actors can successfully express specific emotions through walking movements. But it is in fact difficult to be sure that the actors are expressing emotions through the same walking movements that are used by individuals in the ecological environment. The actors may express specific emotions based on their beliefs of which walking movements accurately display those specific emotions and these may be influenced by cultural stereotypes, wrong practices in their acting training, exaggerated and stylized emotional displays in the media, and the like.

Nevertheless, the assumption that actors do accurately express specific emotions through walking style can be upheld based on two reasons: 1) actors are trained to express emotions in a way that can be perceived by viewers of their performance. If the discrepancy between what the actor wants to express and what the viewer perceives becomes too large then the actor will fail at their profession. 2) The ecological theory of visual perception (Gibson, 1979/1986) argues that the movements used to perceive a specific emotion will be congruent with the
movements used to express the same emotion (discussed in section 2.2.1.). To ensure that remaining problems do not influence the synthetic walkers, only the actors whose emotionally expressive walk is reliably perceived as expressing the emotion intended by the actor will be used for the creation of the synthetic walkers (discussed in detail in section 9.1.).

Accordingly, the actor method for recording walkers offers substantial advantages. Firstly, because actors are actively attempting to express specific emotions through their walking style the resulting data will have less noise than the method used by Troje (2002). Secondly, knowing which specific emotion that the walker is intending to express permits determination of the degree to which these specific emotions can be accurately identified. Accurate identification is defined as when the perceived emotion is congruent with the displayed emotion. Thirdly, by using the acting method for recording walkers the methodological and theoretical problems associated with priming specific emotions in walking style (discussed previously) can be avoided. The data gathered from perceivers is therefore contingent on the quality of the actors (able to be verified through inter-rater reliability) as opposed to the success of the MIP (difficult to verify considering the temporal constraints- discussed previously). Because of these advantages the acting method of recording walkers will be used in the current research.
6.2. Method

6.2.1. Aim

The primary aim of recording walkers is to record a set of walker stimuli that successfully express specific emotions through their walking style. The recorded walks will be used as the stimuli for subsequent perception experiments.

6.2.2. Participants

The sample of ‘walkers’ constituted 17 female and 19 male actors who were paid $50 for their participation. The walkers were recruited from various acting agencies in the Sydney area and through recruitment flyers. The walkers had a mean age of 32.5 (SD = 9.8) years, 2.46 (SD = 5.08, missing scores = 10) years of acting training and a mean of 4.18 (SD = 6.99, missing scores = 8) years of acting experience.

The walkers were told during recruitment that they would be required to walk whilst displaying different emotions (i.e. happiness, sadness, anger, fear and neutral) at each of three levels of intensity (i.e. low, moderate and high). The walkers therefore had sufficient time to think about which acting strategy would create the optimum mental state for acting out the different emotions at varying intensities. The method for displaying each emotion at each level of intensity through gait was freely chosen by each actor walker. Informed consent was obtained from each participant (Appendix A).

6.2.3. Apparatus
Walkers were required to wear specialised clothes (i.e. spandex cat suits) supplied by the researcher to ensure that the Vicon Nexus motion capture system recorded and measured the movement of the walker, as opposed to the movement of the walker’s clothes. The cat suits consisted of black cotton spandex that extended from the wrists to the ankles of the walkers. Additionally the cat suits had a spandex hood that covered the neck and head but left the face open to viewing. Walkers were able to choose the cat suit that best fit their body size (sizes 8-16). To avoid the face of the walker being seen on the video camera, all walkers work a black balaclava leaving only the walker’s eyes and lips visible to the camera. The reflective markers were attached with double sided tape to both sides of their body on the ears, shoulders, elbows, wrists, hips, knees, ankles, insteps of the feet and a single marker on the superior point of the walker’s sternum (i.e. manubrium). Thus a total of 17 markers were used on each walker (see Figure 6.1).

Vicon Nexus (version 1.1, Oxford Metrics Limited) was used to record and measure the walker’s movements. The Vicon motion tracking system consists of 10 infra-red cameras and control hardware and software. The cameras were placed on either side of the walker and facing down the walkway towards the oncoming walker (see Figure 6.2). The individual images of a given marker from each camera are used to calculate a single 3-dimensional coordinate for the marker’s position for each frame of time. Each infra-red marker must be seen by at least two cameras for the 3-dimensional coordinates of the marker to be calculated and recognized by the system. The temporal resolution of the tracking was set to 50 frames per second.
Additionally a full video digital camera (Panasonic NV-MX300EN/A) was used to simultaneously record full-light displays of the walkers. The full video camera recorded the walker’s movements from a frontal perspective due to the greater ecological validity in regards to the ecological theory of visual perception (Gibson, 1979/1986) and the approach/withdrawal dimension of the circumplex model used in this research (see Figure 3.1).

Figure 6.1. The placement of Vicon markers on the bodies of the walkers.
6.2.4. Procedure

Upon entering the movement analysis laboratory, a single participant (i.e. walker) was asked to give informed consent and fill out a pre-screening questionnaire (Appendix B). The walker was then asked to don the specialised clothing provided by the researcher and then have Vicon infra-red markers put onto predesignated points of the body. The walker was told that for each emotion they were required to walk as a healthy individual with unimpeded movement. The participant was instructed that for each emotion they were required to walk from one side of the room to the other (down the corridor of Vicon cameras towards the video...
camera) whilst simultaneously being shown the correct path by the researcher. The neutral walk was recorded first to get a base walk to which other emotion specific walks could be compared. Once the neutral walk was recorded the walker was asked to walk the same path but displaying a specific emotion (i.e. happiness, sadness, anger, and then fear) at one of three levels of intensity (i.e. low, moderate or high).

A minimum of two complete gait cycles was recorded. A gait cycle is defined as the point where a single foot breaks contact from the ground to the point where it is about to break contact with the ground again. This process was repeated for each of the four emotional states (i.e. happiness, sadness, anger, and fear).

6.3. Results and Discussion

6.3.1. Preferred Acting Methods of Actors

Of the 36 actors who attempted to express different emotions through their walking style almost half of the actors (n = 15) refrained from listing which acting method they preferred to use. The remaining walkers (n = 21) almost exclusively used the Stanislavski method (n = 18), followed by the practical method (n = 2) and a single walker said that they used no method at all.

The Stanislavski method acting (Stanislavski, 1949) involves the actor actually embodying the emotion that they intended to display through their walking style. For example, when an actor was attempting to display fear through their walking style they would think of something frightening which consequently primed the actual felt emotion of fear. It can therefore be reasonably assumed that the
walkers using the Stanislavski method experienced the emotions to a certain degree that they were attempting to express.

The emotions displayed through ecologically valid walker recordings are more likely to be perceived by the perceivers in subsequent experiments. The ecological theory of visual perception (Gibson, 1979/1999) holds that our perceptual systems have adapted and attuned to improve the perception of important stimuli in the environment (see section 2.2.1. for further details) like emotions that are expressed through movement. Accordingly, it is reasonable to assume that the walkers that used the Stanislavski method are increasing the likelihood that the displayed emotions will be accurately perceived in subsequent experiments.

The Stanislavski method of acting and the ecological theory of visual perception (Gibson, 1979/1986) are based on similar principles and considerations. Both the Stanislavski method and the ecological theory of visual perception hold one theoretical principle in common; they both argue that there is a direct relationship between the environment and the way an individual acts and that through a lifetime of experience specific behaviours arise under specific purposeful contexts. Individuals are able to make sense of these behaviours by perceiving them (Bilgrave & Deluty, 2004). Therefore according to the ecological perspective the best way to display an emotion that can be perceived by others is for the actor to experience the displayed emotion.

6.3.2. General Trends of Walking Style Patterns
Whilst the main aim of the walker recording was to create the stimuli that will be used in experiments 1 and 2, it is important to note some general patterns that the researcher noticed in the movements that different walkers used to display specific emotions. These general patterns of walking movements were not subjected to any statistical tests because the only perceiver was the researcher who noticed them only during the course of recording walkers and was not part of the original methodological design. Never-the-less these general patterns of walking movement will be considered when hypothesising in subsequent experiments about what movement features will be used by perceivers to discriminate between the different emotions in walking.

Happy walkers were perceived by this researcher in general to have walked quickly and had a bounce in their step. Sad walkers in general walked slower, hung their head and snaked a path of walking. Angry walkers in general walked quickly and seemed to square their shoulders (i.e. very little movement in their torso sway) as they walked. Fearful walkers in general held their hands close to their body and turned their head as if searching the surrounding environment for potential threats. The fearful walkers appeared to be divided into two types: fleeing or cautious. When the researcher questioned the actors about which strategy they adopted after the experiment finished (based on the researcher perceiving two distinct walking styles for fear), the actors explained that they adopted the strategy that corresponded with their interpretation of what they were afraid of in the environment. The first type of fearful walker (i.e. fleeing) interpreted the fearful situation as something to be fled from, thus they tended to walk fast and turn their heads further as if to see if they were still being followed. The second type of fearful walker interpreted the fearful
situation as something they may be approaching (i.e. cautious), thus they adopted a slower walk (sometimes interspersed with a quick step) and turning the head side to side as if to see a possible threat coming from the side.

6.4. Conclusion

In this chapter different methods for the recording of walkers displaying specific emotions have been discussed. It was also described how a set of walkers expressing specific emotions at different levels of intensity were recorded. The recordings of these walkers will be used as stimuli in the following experiments. It has been argued that the recordings of the walkers displaying specific emotions hold ecological validity.
Chapter 7

Experiment 1: Full-light Display of Walkers

7.1. Introduction

In the ecological environment, perceivers view walkers in their natural form. That is, perceivers will have a large amount of information (e.g. gender, ethnicity, body composition) from which to draw their conclusions about which emotion a walker may be displaying through their movements. This experiment will show to perceivers full-light displays of the walkers recorded in the stimulus creation (see chapter 6). Full-light display refers to video recordings of the walkers thus the perceivers will identify the emotions displayed by the walkers in the most ecologically valid format (i.e. their natural form).

Full-light display was used by Montepare et al. (1987) in their study investigating how different emotions are perceived through walking style as walkers in the Montepare et al. study were recorded in black and white (as opposed to full colour or point-light display). Walkers shown to perceivers deviated somewhat from what would be seen in the ecological environment. Nevertheless, Montepare et al. was aware of the possible confounds that exist when using full video display. The walker’s heads were not recorded to avoid confounding the emotional information in gait with the emotional information expressed through the face. Montepare et al. also attempted to control for the possible confound of clothing. All the walkers recorded in the study wore similar sets of comfortable clothes (i.e. jeans and a sweatshirt). However, subtle differences in the style of clothes (e.g. cut of jeans, how loose the sweatshirt was) may have influenced the results. A walker wearing
loose clothes may have hidden some of the gait information that was shown to perceivers and thus biasing the results, especially considering only five walkers were used. In order to control these same confounds in the present study, all walkers were dressed in identical clothes and had their faces covered. Furthermore, the clothing was skin tight (i.e. spandex) ensuring that all of the emotional information displayed in the gait could be seen by perceivers.

Despite controlling for the possible confounds of facial expression and clothing, other possible confounds still exist in the full-light display used in this experiment. Perceivers can still see the body composition of the walker (e.g. amount of fat or muscle) which may influence how different emotions are perceived. The gender of the walker is also easily recognized due to the revealing nature of skin tight clothing (e.g. breasts on female walkers). However, in this experiment these variables are intentionally left uncontrolled. The influence of these same variables will be minimised when perceivers view point-light walkers (chapter 8: Experiment 2) and eliminated completely in the synthetic walkers (chapter 9: Experiment 3).

This experiment will aim to answer the previously discussed research questions (see chapter 5). Specifically: 1) Can perceivers reliably identify the emotions that a walker is displaying through their walking style? 2) Is the alarm hypothesis supported when perceiving different emotions through walking style? 3) Does the gender of the walker influence the perception of different emotions displayed through walking style?
The specific independent and dependent variables used in this experiment will depend on the specific statistical analysis used to investigate the previously discussed research questions. This experiment will use four independent variables:

1) Displayed emotion; the emotion that the walkers intended to display through their walking style. 2) Accuracy; whether the perceived emotion was congruent with the displayed emotion. 3) Intensity; the intended level of displayed emotional intensity by the walkers. 4) Gender; the gender of the walker. This experiment will also use three dependent variables: 1) Perceived emotion; the emotion that perceivers categorised the walkers as displaying. 2) Reaction time; the time perceivers required before categorising the emotion that the walkers were displaying. 3) Perceiver ratings; the perceiver rated intensity level of the emotion perceived as being displayed by the point-light walker.

The above research questions will be investigated through several specific hypotheses. Conflicting theoretical arguments give rise to hypotheses that directly compete with alternative hypotheses. The following specific hypotheses (abbreviated in Table 7.1) will be tested in this experiment: 1) Perceivers will reliably identify above chance the specific emotion that a walker is displaying through their walking style. 2) Male full-light walkers will be perceived as displaying significantly more approach emotions (i.e. happiness and anger) than withdrawal emotions (i.e. sadness and fear). 3) Female full-light walkers will be perceived as displaying significantly more withdrawal emotions (i.e. sadness and fear) than approach emotions (i.e. happiness and anger). 4) Male full-light walkers displaying anger will be identified significantly more than any other emotion displayed by male walkers. 5) Full-light walkers displaying anger will be identified
Table 7.1

Abbreviations for Each Hypothesis for this Full-light Walker Experiment

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis&lt;sup&gt;a,b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification Rates</td>
<td>Emotion &gt; Chance</td>
</tr>
<tr>
<td>Male: Happy and Anger &gt; Sad and Fear</td>
<td>Male: Anger &gt; All other Emotions</td>
</tr>
<tr>
<td>Female: Sad and Fear &gt; Happy and Anger</td>
<td>Male Anger &gt; Female Anger</td>
</tr>
<tr>
<td>Male: Anger &gt; All other Emotions</td>
<td>Female: Happy &gt; All other Emotions</td>
</tr>
<tr>
<td>Male Anger &gt; Female Anger</td>
<td>Female Happy &gt; Male Happy</td>
</tr>
</tbody>
</table>

Identified Emotion

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis&lt;sup&gt;a,b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity Ratings</td>
<td>Anger &lt; All other Emotions</td>
</tr>
<tr>
<td>Fear &lt; Happy and Sad</td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td>Female Fear &lt; Male Fear</td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td>Identification Times</td>
<td>Happy &lt; All other Emotions</td>
</tr>
<tr>
<td>Anger &lt; All other Emotions</td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td>Female Fear &lt; Male Fear</td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td>Happy and Anger &lt; Sad and Fear</td>
<td>Anger &gt; All other Emotions</td>
</tr>
</tbody>
</table>

Note. Some of these hypotheses may appear contradictory because they are derived from opposing arguments or evidence. <sup>a</sup> ‘<’ denotes the direction of the specific hypothesis. <sup>b</sup> Any expression preceding ‘:’ pertains to a specific condition applicable to that hypothesis.

by perceivers significantly more when the walker is male than when the walker is female. 6) Female full-light walkers displaying happiness will be identified significantly more than any other emotion displayed by female walkers. 7) Full-light walkers displaying happiness will be identified by perceivers significantly more when the walker is female than when the walker is male. 8) Perceivers will be able to accurately identify a lower intensity of displayed anger in full-light walkers than
for all other emotions. 9) Perceivers will be able to accurately identify a lower intensity of displayed fear in full-light walkers than either happiness or sadness. 10) Perceivers will rate correctly identified angry full-light walkers as expressing a significantly lower level of intensity when the walker is male as compared to female. 11) Perceivers will rate correctly identified fearful full-light walkers as expressing a significantly lower level of intensity when the walker is female as compared to male. 12) Happiness displayed through walking style will be identified significantly faster than all other emotions. 13) Anger will be identified significantly faster than all other emotions. 14) Anger will be identified significantly faster in male walkers than female walkers. 15) Fear will be identified significantly faster in female walkers than male walkers. 16) Negative emotions will be identified significantly slower than positive emotions. 17) Anger will be identified significantly slower than all other emotions.

7.2. Method

7.2.1. Participants

The sample of ‘perceivers’ comprised four males and 34 female (N = 38) first year psychology students (from the University of Western Sydney). The sample had a mean age of 22.61 years (SD = 8.88). All perceivers had normal or corrected to normal vision. The perceivers were given course credit for their participation in the experiment. Informed consent was obtained from each perceiver (Appendix C).

7.2.2. Materials

The set of full-light walkers that was used as stimuli (Appendix D) was created from the full video gait recordings of the participants from the walker recording part
of this research. To avoid confusion, the individual recordings of a single actor walker will be described separately and hereafter referred to as different walkers. For example, a single actor walker was recorded 13 times (4 emotions x 3 levels of intensities + 1 neutral) creating 13 separate walker stimuli (see section 6.2.3. for further details). A total of 423 walkers (happy = 102, sad = 99, anger = 93, fear = 94, neutral = 35) was shown to perceivers. All displayed intensity levels were more or less equally represented for each emotion (frequency range = 30-35). A total of 45 walkers (happy = 6, sad = 9, anger = 15, fear = 14, neutral = 1) were not shown to perceivers because of equipment malfunctions during recording.

The experiment control software Alvin (version 1.19, Hillenbrand & Gayvert, 2005) was used to show the full-light display walkers to the perceivers and to record the reaction time (ms) of the perceivers. For each full-light walker presented, five categorical buttons that correspond to each of the five emotions (i.e. happiness, sadness, anger, fear and neutral) were made available (see Figure 7.1). The program required the perceiver to click on one of the categorical buttons. The reaction time from the initial showing of the full-light walker to the pressing of the categorical button was automatically recorded by the program. Below these categorical buttons were another set of buttons enabling the perceiver to rate the intensity of the specific emotion that the walker was perceived as feeling. There were five rating buttons corresponding to a 5-point Likert scale (1= Low Intensity, 5= High Intensity). The participant was required to click the button that best described how intense the emotion that the walker was perceived as feeling. Because neutral emotion only has a single level of intensity, when neutral emotion is chosen only the rating button ‘5’ was enabled to be clicked. All neutral identifications subsequently had an
Figure 7.1. The Alvin program display that perceivers used to make their judgements about which emotion each full-light walker was displaying and their ratings about how intense the displayed emotion was perceived as.

emotional intensity rating of 5. The program displayed to perceivers a walker walking towards them. As discussed previously (see section 3.2.4.), the frontal viewing perspective was chosen due to the increased ecological validity of the stimuli in regards to the ecological theory of visual perception (Gibson, 1979/1986). This was followed by a blank screen for two seconds, before moving onto the next full-light walker.

7.2.3. Apparatus

Computers with the Alvin computer program were used to display the full-light walkers to perceivers. All computer monitors were of identical size (i.e. 19 inch). A
single chair was positioned in front of each computer so each seated participant had an unobstructed view whilst remaining free from the perceptual influence of other participants. The perceivers were able to adjust the chair to a comfortable position for viewing the computer screen.

Additionally a short open ended questionnaire (Appendix E) was used. The questionnaire was divided into four categories corresponding to each of the four emotions. For each emotion category the questionnaire asked a single question: “On reflection, what strategies do you think you used for judging which emotion each walker was expressing? For example, did you pay attention to a particular part of the display? For emotion categories where you think you used no particular strategy, but rather guessing was the strategy used, then this should be explicitly stated.”

7.2.4. Procedure

After gaining informed consent (Appendix C), perceivers were seated at a computer with the Alvin program installed. They were told they would view a series of walkers shown in full video display format. It was also explained to the perceivers that the walkers will be walking with one of five emotional states: happiness, sadness, anger, fear or neutral. The perceivers were required to record which emotion the walker was feeling by clicking the button on the screen that corresponded to the emotion they perceived. The perceivers were asked to make their judgments as quickly and as accurate as possible. It was explained to the perceivers that after making a judgement about which emotion the walker was feeling, they would be required to rate the intensity of that same emotion on the 5-point Likert scale (1= Low Intensity, 5= High Intensity) which was also situation on
the computer screen (see Figure 7.1). It was explained to the perceivers that since neutral emotion is an absence of emotion, it could therefore not have different levels of emotional intensity. As such when the perceiver chose neutral as the emotion the walker was displaying, the only rating button that the computer would allow the perceiver to click was ‘5’. All perceivers were given the opportunity to verify their understanding of the instructions.

At the conclusion of the presentation the participants were given a short open ended questionnaire which required perceivers to describe any strategies, if any, they used to make their judgements. The participants were told that when they merely guessed in their judgements then they should explicitly state so. The experiment took a maximum of 90 minutes to complete though few participants required the entire 90 minutes.

7.3. Results

7.3.1. The Identification of Specific Emotions

Each displayed emotion was accurately perceived by perceivers well above chance levels (i.e. 20%). As can be seen in Table 7.2, sadness was identified most accurately, followed by fear, which was followed by happiness, then neutral and anger having the poorest identification rates. Furthermore, this pattern was supported for both genders of walkers (Table 7.3) though sad, anger and fear appeared to be identified better when the walker was female.


Table 7.2

*The Total Frequency of Perceived Emotion Categorisations Compared to the Displayed Emotion of Full-Light Walkers.*

<table>
<thead>
<tr>
<th>Perceived Emotion Category</th>
<th>Happy</th>
<th>Sad</th>
<th>Anger</th>
<th>Fear</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>2253</td>
<td>103</td>
<td>605</td>
<td>101</td>
<td>225</td>
</tr>
<tr>
<td></td>
<td>(58%)</td>
<td>(3%)</td>
<td>(17%)</td>
<td>(3%)</td>
<td>(17%)</td>
</tr>
<tr>
<td>S</td>
<td>170</td>
<td>2847</td>
<td>306</td>
<td>537</td>
<td>222</td>
</tr>
<tr>
<td></td>
<td>(4%)</td>
<td>(76%)</td>
<td>(9%)</td>
<td>(15%)</td>
<td>(17%)</td>
</tr>
<tr>
<td>A</td>
<td>574</td>
<td>159</td>
<td>1820</td>
<td>193</td>
<td>139</td>
</tr>
<tr>
<td></td>
<td>(15%)</td>
<td>(4%)</td>
<td>(51%)</td>
<td>(5%)</td>
<td>(17%)</td>
</tr>
<tr>
<td>F</td>
<td>109</td>
<td>88</td>
<td>205</td>
<td>2407</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>(3%)</td>
<td>(2%)</td>
<td>(6%)</td>
<td>(67%)</td>
<td>(2%)</td>
</tr>
<tr>
<td>N</td>
<td>770</td>
<td>565</td>
<td>598</td>
<td>334</td>
<td>712</td>
</tr>
<tr>
<td></td>
<td>(20%)</td>
<td>(15%)</td>
<td>(17%)</td>
<td>(9%)</td>
<td>(54%)</td>
</tr>
<tr>
<td>Total</td>
<td>3876</td>
<td>3762</td>
<td>3534</td>
<td>3572</td>
<td>1330</td>
</tr>
</tbody>
</table>

*Note.* The percentage of the total perceived emotion categorisations for each displayed emotion is given in corresponding parentheses.

Wagner (1993) however, pointed out that expressing data for non-verbal behaviour in raw frequency format often results in three interrelated types of error: inappropriate measures of accuracy, inaccurate calculations of chance, and the misapplied use of $\chi^2$ and binomial statistical analyses. Wagner (1993) illustrated how a perceiver’s bias to respond with a particular category can render accuracy rates meaningless. If a perceiver responds to a particular category (e.g. happy) every time then happiness will be correctly perceived with 100% accuracy. However, in this example the result would represent a perceiver response bias towards selecting...
Table 7.3

The Total Frequency of Perceived Emotion Categorisations Compared to the Displayed Emotion of Full-Light Walkers Split by Walker Gender.

<table>
<thead>
<tr>
<th>Displayed Emotion Category</th>
<th>Female Full-light Walkers</th>
<th>Male Full-light Walkers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happy (91%)</td>
<td>Sad (15%)</td>
</tr>
<tr>
<td>H</td>
<td>1084 (56%)</td>
<td>23 (1%)</td>
</tr>
<tr>
<td>S</td>
<td>94 (5%)</td>
<td>1418 (83%)</td>
</tr>
<tr>
<td>Perceived Emotion Category</td>
<td>A</td>
<td>258 (14%)</td>
</tr>
<tr>
<td>F</td>
<td>37 (2%)</td>
<td>52 (3%)</td>
</tr>
<tr>
<td>N</td>
<td>351 (19%)</td>
<td>165 (10%)</td>
</tr>
<tr>
<td>Total</td>
<td>1824</td>
<td>1710</td>
</tr>
</tbody>
</table>

Note. The percentage of the total perceived emotion categorisations for each displayed emotion is given in corresponding parentheses.

happiness as opposed to any real indication of how well happiness is perceived.

There is thus an inherent relationship between the displayed category (assuming that the category is displayed correctly) and the response category (assuming that the
perceiver can actually identify the displayed category). Wagner (1993) thus suggested converting the total frequency scores to \( H_u \) scores which accounts for the conditional probability that a stimulus item is correctly perceived given that it is successfully displayed. This more stringent restriction consequently means the \( H_u \) scores are lower than the corresponding percentage of total emotion categorisations derived from the raw frequency scores. The calculation of \( H_u \) scores can be made in reference to Table 7.4 by equation 1.

Equation 1:  \[
H_u(a) = \frac{a}{a + b + c + d + e} \times \frac{a}{a + f + k + p + u}
\]

Chance levels for a given response category may also be miscalculated due to observer response bias. Using a priori determined chance level (i.e. 100%/5 emotion response categories = 20% chance) assumes random selection and thus each category has an equal chance of being selected. However, there is an inherent relationship between the displayed category and the response category. Therefore in the majority of studies on non-verbal communication, perceivers will be biased to respond more to the displayed category of the stimulus item (Wagner, 1993). Chance levels for each cell of the confusion matrix must therefore take into account the influence of both the proportion of responses in each response category (i.e. perceived emotion) and each stimulus category (i.e. displayed emotion). After adjusting for observer response bias each cell of the confusion matrix will therefore have a different level of chance. The calculation of adjusted chance levels (i.e. \( H_c \)) for each cell of the design can be made in reference to Table 7.4 by equation 2.

Equation 2:  \[
H_c(a) = \left( \frac{a + b + c + d + e}{N} \right) \times \left( \frac{a + f + k + p + u}{N} \right)
\]
Table 7.4

**Example Confusion Matrix to Illustrate how Hu Scores and the Corresponding Levels of Chance (Hc) can be Calculated.**

<table>
<thead>
<tr>
<th>Displayed Emotion Category</th>
<th>H</th>
<th>S</th>
<th>A</th>
<th>F</th>
<th>N</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Emotion Category</td>
<td>H</td>
<td>a</td>
<td>b</td>
<td>c</td>
<td>d</td>
<td>e/a+b+c+d+e</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td>f</td>
<td>g</td>
<td>h</td>
<td>i</td>
<td>j/f+g+h+i+j</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>k</td>
<td>l</td>
<td>m</td>
<td>n</td>
<td>o/k+l+m+n+o</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>p</td>
<td>q</td>
<td>r</td>
<td>s</td>
<td>t/p+q+r+s+t</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>u</td>
<td>v</td>
<td>w</td>
<td>x</td>
<td>y/u+v+w+x+y</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>a+f</td>
<td>b+g</td>
<td>c+h</td>
<td>d+i</td>
<td>e+j</td>
<td>N</td>
</tr>
<tr>
<td></td>
<td>+k+</td>
<td>+l+</td>
<td>+m+</td>
<td>+n+</td>
<td>+o+</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p+u</td>
<td>q+v</td>
<td>r+w</td>
<td>s+x</td>
<td>t+y</td>
<td></td>
</tr>
</tbody>
</table>

*Note.* Entries are frequencies

Additionally, the analysis of frequency data requires a statistical analysis that does not assume an interval level of measurement such as $\chi^2$ or tests based on a binomial distribution. However, these statistical tests assume that the frequencies are independent of each other. The assumption of independence is clearly violated in this study as each perceiver responded to each stimulus item which included multiple walkers expressing the same emotion. Both $H_u$ and $H_c$ are expressed as proportions between 0 and 1 and may therefore be interpreted as percentages with a ratio level of measurement. Wagner’s (1993) suggestion to convert the total frequency scores to $H_u$ scores and comparing $H_u$ to a modified chance level ($H_c$) for each cell of the design thus allows the use of statistical tests that assume an interval level of measurement (i.e. t-tests and ANOVAs). Furthermore, the assumption of
independence can be bypassed with the converted $H_u$ and $H_c$ scores by using repeated measures statistical analyses (i.e. paired-sample t-tests and repeated measures ANOVAs). The raw frequency scores for each perceiver were thus converted to $H_u$ scores and $H_c$ was calculated for each cell of the design. The mean $H_u$ scores compared to the mean $H_c$ for the total number of full-light walkers is shown in Table 7.5 and separated according to the gender of the walker in Table 7.6.

The conversion of the total frequency scores to $H_u$ scores showed a different pattern in the data. As can be seen in Table 7.5, fear was identified most accurately, followed by sadness, which was followed by happiness, then anger and neutral having the relatively poorest identification rates. Furthermore, this pattern was supported for both genders of walkers (Table 7.6) though each emotion appeared to be identified better when the walker was female.

To investigate whether the correct emotion was identified five separate 5 (perceived emotion) x 2 ($H_u$ vs. $H_c$) x 2 (gender) repeated measures ANOVAs were conducted for each displayed emotion. All $H_u$ and $H_c$ scores were arcsine transformed for each ANOVA and subsequent post-hoc analyses. Outliers were identified in multiple cells for each of the separate ANOVAs. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of covariance was not met in any of the five ANOVAs for the main effect of perceived emotion nor for any of the interactions involving perceived emotion in. The Greenhouse-Geisser adjustment to the degrees of freedom was used for all main effects and interactions where the assumption of homogeneity of covariance was not met.
Table 7.5

*The Mean Hu Scores of Perceived Emotion Categorisations Compared to the Displayed Emotion of Full-Light Walkers.*

<table>
<thead>
<tr>
<th>Perceived Emotion Category</th>
<th>Displayed Emotion Category</th>
<th>Happy</th>
<th>Sad</th>
<th>Anger</th>
<th>Fear</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td></td>
<td>.406 *</td>
<td>.001</td>
<td>.033</td>
<td>.001</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.047)</td>
<td>(.047)</td>
<td>(.045)</td>
<td>(.045)</td>
<td>(.018)</td>
</tr>
<tr>
<td>S</td>
<td></td>
<td>.003</td>
<td>.533 *</td>
<td>.007</td>
<td>.023</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.061)</td>
<td>(.060)</td>
<td>(.056)</td>
<td>(.057)</td>
<td>(.057)</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>.029</td>
<td>.003</td>
<td>.325 *</td>
<td>.004</td>
<td>.007</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.042)</td>
<td>(.041)</td>
<td>(.038)</td>
<td>(.038)</td>
<td>(.015)</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>.003</td>
<td>.001</td>
<td>.008</td>
<td>.567 *</td>
<td>.009</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.044)</td>
<td>(.042)</td>
<td>(.040)</td>
<td>(.040)</td>
<td>(.015)</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>.056 *</td>
<td>.030</td>
<td>.038</td>
<td>.010</td>
<td>.132 *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.045)</td>
<td>(.043)</td>
<td>(.041)</td>
<td>(.041)</td>
<td>(.016)</td>
</tr>
</tbody>
</table>

*Note.* The mean $H_c$ level for each cell is given in corresponding parentheses. *denotes a $Hu$ score that is higher than the corresponding $H_c$ score.

A 5 (perceived emotion) x 2 ($Hu$ vs. $H_c$) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of happiness. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, $F(1.85, 148) = 560.14$, $p < .001$, partial $\eta^2 = .94$, obs. power = 1.00; $Hu vs H_c$, $F(1, 37) = 1541.76$, $p < .001$, partial $\eta^2 = .98$, obs. power = 1.00; walker gender, $F(1, 37) = 41.11$, $p < .001$, partial $\eta^2 = .53$, obs. power = 1.00. All interactions were also significant: Perceived emotion by $Hu vs H_c$, $F(1.58, 58.30) = 1487.57$, $p < .001$, partial $\eta^2 = .98$, obs. power = 1.00; perceived emotion by gender, $F(1.50, 55.45) = 10.25$, $p < .001$, partial $\eta^2 = .22$, obs. power = 0.95; $Hu vs H_c$ by gender, $F(1, 37) = 25.16$, $p < .001$, partial $\eta^2 =$
Table 7.6

The Mean Hu Scores of Perceived Emotion Categorisations Compared to the
Displayed Emotion for Full-Light Walkers Split by Walker Gender.

<table>
<thead>
<tr>
<th>Displayed Emotion Category</th>
<th>Happy</th>
<th>Sad</th>
<th>Anger</th>
<th>Fear</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female Full-light Walkers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>.440 *</td>
<td>.001</td>
<td>.033</td>
<td>.001</td>
<td>.014</td>
</tr>
<tr>
<td></td>
<td>(.050)</td>
<td>(.047)</td>
<td>(.044)</td>
<td>(.045)</td>
<td>(.017)</td>
</tr>
<tr>
<td>S</td>
<td>.003</td>
<td>.576 *</td>
<td>.006</td>
<td>.027</td>
<td>.021</td>
</tr>
<tr>
<td></td>
<td>(.068)</td>
<td>(.064)</td>
<td>(.060)</td>
<td>(.063)</td>
<td>(.024)</td>
</tr>
<tr>
<td>Perceived Emotion Category</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>.031</td>
<td>.002</td>
<td>.372 *</td>
<td>.005</td>
<td>.005</td>
</tr>
<tr>
<td></td>
<td>(.043)</td>
<td>(.041)</td>
<td>(.038)</td>
<td>(.039)</td>
<td>(.015)</td>
</tr>
<tr>
<td>F</td>
<td>.001</td>
<td>.002</td>
<td>.009</td>
<td>.594 *</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td>(.045)</td>
<td>(.042)</td>
<td>(.039)</td>
<td>(.041)</td>
<td>(.016)</td>
</tr>
<tr>
<td>N</td>
<td>.060 *</td>
<td>.016</td>
<td>.032</td>
<td>.020</td>
<td>.168 *</td>
</tr>
<tr>
<td></td>
<td>(.039)</td>
<td>(.036)</td>
<td>(.034)</td>
<td>(.035)</td>
<td>(.013)</td>
</tr>
</tbody>
</table>

| **Male Full-light Walkers** |        |       |       |        |         |
| H                          | .384 * | .003  | .035  | .002   | .022 *  |
|                            | (.049) | (.049)| (.046)| (.046) | (.016)  |
| S                          | .002   | .506 *| .010  | .020   | .007    |
|                            | (.056) | (.056)| (.053)| (.053) | (.019)  |
| Perceived Emotion Category |        |       |       |        |         |
| A                          | .033   | .005  | .298 *| .024   | .010    |
|                            | (.043) | (.043)| (.041)| (.041) | (.015)  |
| F                          | .004   | .001  | .012  | .539 * | .001    |
|                            | (.040) | (.040)| (.038)| (.038) | (.013)  |
| N                          | .052 * | .043  | .041  | .023   | .109 *  |
|                            | (.048) | (.049)| (.046)| (.046) | (.016)  |

*Note. The mean Hu level for each cell is given in corresponding parentheses. * denotes a Hu score that is higher than the corresponding Hu score.*

.41, obs. power = 1.00; and perceived emotion by Hu vs Hu by gender, \(F(1.44, 53.41) = 15.50, p < .001, \partial \eta^2 = .30, \) obs. power = .99. Descriptive statistics for the interactions are shown in Figure 7.2.
a) Female Walkers

b) Male Walkers

Figure 7.2. Mean Hu and Hc scores (proportions) for each perceived emotion when happiness was displayed by a) female and b) male full-light walkers. Error bars depict 95% confidence intervals.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not
inform on the investigation of which emotion is perceived significantly above chance when the full-light walkers were displaying happiness and thus will not be discussed here. The remaining four relevant post-hoc comparisons all reached significance. Happy full-light walkers were perceived as displaying happiness significantly above chance for both female, $t(37) = 40.78, p < .05$; and male walkers, $t(37) = 30.52, p < .05$. Happy full-light walkers were also perceived as displaying neutral emotion significantly above chance but only in female walkers, $t(37) = 3.92$, $p < .05$. Happy full-light walkers were correctly perceived significantly more in female walkers than male walkers, $t(37) = 4.18, p < .05$. The results therefore suggest that when a full-light walker displays happiness then perceivers will also perceive the walker as displaying happiness. However, happiness was identified better when the walker was female. The results also indicate that happy full light walkers can be confused as displaying neutral emotion but only in female walkers.

A 5 (perceived emotion) x 2 (H vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of sadness. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, $F(1.46, 54.07) = 1567.32, p < .001$, partial $\eta^2 = .98$, obs. power = 1.00; H vs Hc, $F(1, 37) = 1483.75$, $p < .001$, partial $\eta^2 = .98$, obs. power = 1.00; walker gender, $F(1, 37) = 8.89, p = .01$, partial $\eta^2 = .19$, obs. power = .84. All interactions were also significant: Perceived emotion by H vs Hc, $F(1.30, 48.13) = 2098.53, p < .001$, partial $\eta^2 = .98$, obs. power = 1.00; perceived emotion by gender, $F(1.35, 50.06) = 53.52, p < .001$, partial $\eta^2 = .59$, obs. power = 1.00; H vs Hc by gender, $F(1, 37) = 17.14, p < .001$, partial $\eta^2 = .32$, obs. power = .98; and perceived emotion by H vs Hc by gender, $F(1.18, 43.97)$
$= 27.69$, $p < .001$, partial $\eta^2 = .43$, obs. power = 1.00. Descriptive statistics for the interactions are shown in Figure 7.3.

a) Female Walkers

![Graph showing mean Hu and Hc scores for female walkers.]

b) Male Walkers

![Graph showing mean Hu and Hc scores for male walkers.]

Figure 7.3. Mean Hu and Hc scores (proportions) for each perceived emotion when sadness was displayed by a) female and b) male full-light walkers. Error bars depict 95% confidence intervals.
All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above chance when the full-light walkers were displaying sadness and thus will not be discussed here. The remaining three relevant post-hoc comparisons all reached significance. Sad full-light walkers were perceived as displaying sadness significantly above chance for both female, \( t(37) = 41.39, p < .05 \); and male walkers, \( t(37) = 39.60, p < .05 \). Sad full-light walkers were correctly perceived significantly more in female walkers than male walkers, \( t(37) = 5.92, p < .05 \). The results therefore suggest that when a full-light walker displays sadness then perceivers will also perceive the walker as displaying sadness. However, the results indicate that sadness was identified better when the walker was female.

A 5 (perceived emotion) x 2 (H vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of anger. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, \( F(1.68, 62.15) = 346.27, p < .001 \), partial \( \eta^2 = .90 \), obs. power = 1.00; HvsHc, \( F(1, 37) = 632.98, p < .001 \), partial \( \eta^2 = .95 \), obs. power = 1.00; walker gender, \( F(1, 37) = 11.52, p < .001 \), partial \( \eta^2 = .95 \), obs. power = .91. All interactions were also significant:

Perceived emotion by HvsHc, \( F(1.45, 42.41) = 854.37, p < .001 \), partial \( \eta^2 = .96 \), obs. power = 1.00; perceived emotion by gender, \( F(1.45, 53.45) = 16.10, p < .001 \), partial \( \eta^2 = .30 \), obs. power = 1.00; HvsHc by gender, \( F(1, 37) = 29.18, p < .001 \), partial \( \eta^2 = .44 \), obs. power = 1.00; and perceived emotion by HvsHc by gender, \( F(1.32, 48.96) = 22.15, p < .001 \), partial \( \eta^2 = .37 \), obs. power = 1.00. Descriptive statistics for the interactions are shown in Figure 7.4.
a) Female Walkers

![Graph showing mean Hu and Hc scores for perceived emotions]

b) Male Walkers

![Graph showing mean Hu and Hc scores for perceived emotions]

*Figure 7.4.* Mean Hu and Hc scores (proportions) for each perceived emotion when anger was displayed by a) female and b) male full-light walkers. Error bars depict 95% confidence intervals.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not
inform on the investigation of which emotion is perceived significantly above chance when the full-light walkers were displaying anger and thus will not be discussed here. The remaining three relevant post-hoc comparisons all reached significance. Angry full-light walkers were perceived as displaying anger significantly above chance for both female, $t(37) = 25.04, p < .05$; and male walkers, $t(37) = 25.10, p < .05$. Angry full-light walkers were correctly perceived significantly more in female walkers than male walkers, $t(37) = 4.62, p < .05$. The results therefore suggest that when a full-light walker displays anger then perceivers will also perceive the walker as displaying anger. However, anger was identified better when the walker was female.

A 5 (perceived emotion) x 2 (H vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of fear. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, $F(1.40, 54.07) = 1070.15, p < .001$, partial $\eta^2 = .97$, obs. power = 1.00; H vs Hc, $F(1, 37) = 767.45, p < .001$, partial $\eta^2 = .95$, obs. power = 1.00; walker gender, $F(1, 37) = 4.35, p = .04$, partial $\eta^2 = .11$, obs. power = .53. Of the four possible interactions three were significant: Perceived emotion by H vs Hc, $F(1.24, 45.81) = 1327.35, p < .001$, partial $\eta^2 = .97$, obs. power = 1.00; perceived emotion by gender, $F(1.18, 43.64) = 12.45, p < .001$, partial $\eta^2 = .25$, obs. power = .96; and perceived emotion by H vs Hc by gender, $F(1.10, 40.65) = 7.21, p = .01$, partial $\eta^2 = .16$, obs. power = .77. However, the interaction H vs Hc by gender was not significant, $F(1, 37) = 3.60, p = .07$, partial $\eta^2 = .09$, obs. power = .46. Descriptive statistics for the interactions are shown in Figure 7.5.
a) Female Walkers

![Bar chart showing mean Hu and Hc scores for each perceived emotion when fear was displayed by female walkers. Error bars depict 95% confidence intervals.]

b) Male Walkers

![Bar chart showing mean Hu and Hc scores for each perceived emotion when fear was displayed by male walkers. Error bars depict 95% confidence intervals.]

*Figure 7.5.* Mean Hu and Hc scores (proportions) for each perceived emotion when fear was displayed by a) female and b) male full-light walkers. Error bars depict 95% confidence intervals.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above
chance when the full-light walkers were displaying fear and thus will not be discussed here. The remaining three relevant post-hoc comparisons are described here. Two of the three paired sample t-tests reached significance. Fearful full-light walkers were perceived as displaying fear significantly above chance for both female, $t(37) = 31.46, p < .05$; and male walkers, $t(37) = 31.02, p < .05$. There was no significant difference in the correct perception of fearful full-light walkers between female walkers than male walkers, $t(37) = 2.71, p > .05$. The results therefore suggest that when a full-light walker displays fear then perceivers will also perceive the walker as displaying fear.

A 5 (perceived emotion) x 2 (Hu vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of neutral. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, $F(1.14, 42.09) = 89.20, p < .001$, partial $\eta^2 = .71$, obs. power = 1.00; Hu vs Hc, $F(1, 37) = 163.07, p < .001$, partial $\eta^2 = .82$, obs. power = 1.00; walker gender, $F(1, 37) = 37.55, p < .001$, partial $\eta^2 = .50$, obs. power = 1.00. All interactions were also significant: Perceived emotion by Hu vs Hc, $F(1.09, 40.47) = 147.19, p < .001$, partial $\eta^2 = .80$, obs. power = 1.00; perceived emotion by gender, $F(1.37, 50.49) = 18.60, p < .001$, partial $\eta^2 = .33$, obs. power = 1.00; Hu vs Hc by gender, $F(1, 37) = 31.35, p < .001$, partial $\eta^2 = .46$, obs. power = 1.00; and perceived emotion by Hu vs Hc by gender, $F(1.27, 46.91) = 25.30, p < .001$, partial $\eta^2 = .41$, obs. power = 1.00.

Descriptive statistics for the interactions are shown in Figure 7.6.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not
a) Female Walkers

![Graph showing mean Hu and Hc scores for perceived emotions when neutral was displayed by female walkers.]

b) Male Walkers

![Graph showing mean Hu and Hc scores for perceived emotions when neutral was displayed by male walkers.]

*Figure 7.6.* Mean Hu and Hc scores (proportions) for each perceived emotion when neutral was displayed by a) female and b) male full-light walkers. Error bars depict 95% confidence intervals.

inform on the investigation of which emotion is perceived significantly above chance when the full-light walkers were displaying neutral and thus will not be discussed here. The remaining four relevant post-hoc comparisons are described
Two of the four paired sample t-tests reached significance. Neutral full-light walkers were perceived as displaying neutral significantly above chance for both female, \( t(37) = 11.06, p < .05 \); and male walkers, \( t(37) = 11.46, p < .05 \). Neutral full-light walkers were correctly perceived significantly more in female walkers than male walkers, \( t(37) = 5.01, p < .05 \). Additionally neutral full-light walkers were not perceived as displaying happiness significantly above chance in male walkers, \( t(37) = .86, p > .05 \). The results therefore suggest that when a full-light walker displays neutral emotion then perceivers will also perceive the walker as displaying neutral emotion. However, neutral was identified better when the walker was female.

In each of the repeated measures ANOVAs conducted it was found that the emotion displayed was the emotion perceived significantly above chance. However, this analysis does not show which emotions are perceived better than others. Thus another 5 (Identified emotion) x 2 (H vs H) x 2 (walker gender) repeated measures ANOVA was conducted for the correctly perceived emotions (see the bolded diagonals of Table 7.6). The assumption of homogeneity of covariance was met for all main effects and interactions. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, \( F(3.51, 130.03) = 268.51, p < .001 \), partial \( \eta^2 = .88 \), obs. power = 1.00; H vs H, \( F(1, 37) = 3160.96, p < .001 \), partial \( \eta^2 = .99 \), obs. power = 1.00; walker gender, \( F(1, 37) = 52.10, p < .001 \), partial \( \eta^2 = .59 \), obs. power = 1.00. There were also two significant interactions: Identified emotion by H vs H, \( F(3.54, 130.87) = 275.29, p < .001 \), partial \( \eta^2 = .88 \), obs. power = 1.00; and H vs H by gender, \( F(1, 37) = 48.47, p < .001 \), partial \( \eta^2 = .57 \), obs. power = 1.00. Descriptive statistics for the interactions are shown in Figure 7.7.
a) Female Walkers

![Graph showing mean Hu and Hc scores for female walkers for each emotion.]

b) Male Walkers

![Graph showing mean Hu and Hc scores for male walkers for each emotion.]

*Figure 7.7.* Mean Hu and Hc scores (proportions) for each correctly perceived emotion when displayed by a) female and b) male full-light walkers. Error bars depict 95% confidence intervals.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of how well each emotion is relatively identified and
thus will not be discussed here. The Hu scores for each emotion were compared with
the Hu scores for each other emotion. The post-hoc comparisons were done
separately for each walker gender. Thus the remaining 20 relevant post-hoc
comparisons are described here. Sadness was identified significantly more than
happiness in both female, \( t(37) = 11.11, p < .05 \); and male full-light walkers, \( t(37) =
8.02, p < .05 \). Happiness was identified significantly more than anger in both female,
\( t(37) = 4.05, p < .05 \); and male full-light walkers, \( t(37) = 5.16, p < .05 \). Fear was
identified significantly more than happiness in both female, \( t(37) = 7.80, p < .05 \);
and male full-light walkers, \( t(37) = 8.87, p < .05 \). Happiness was identified
significantly better than neutral in both female, \( t(37) = 13.92, p < .05 \); and male
walkers, \( t(37) = 20.55, p < .05 \). Sadness was identified significantly better than anger
in both female, \( t(37) = 13.33, p < .05 \); and male walkers, \( t(37) = 14.13, p < 
.05 \). Sadness was identified significantly better than neutral for both female, \( t(37) =
21.63, p < .05 \); and male walkers, \( t(37) = 25.03, p < .05 \). Fear was identified
significantly better than anger in both female, \( t(37) = 12.35, p < .05 \); and male
walkers, \( t(37) = 12.97, p < .05 \). Anger was identified significantly better than neutral
in both female, \( t(37) = 9.83, p < .05 \); and male walkers, \( t(37) = 13.29, p < .05 \). Fear
was also identified significantly better than neutral in both female, \( t(37) = 21.24, p <
.05 \); and male walkers, \( t(37) = 24.75, p < .05 \). However, there was no significant
difference between the identification rates for sadness and fear for both female, \( t(37)
= .80, p > .05 \); and male walkers, \( t(37) = 2.45, p > .05 \). The results indicate that there
is a clear order in how well the different emotions are identified. Sadness and fear
are identified the best and equally well as each other, followed by happiness, then
anger and neutral was identified the relative worst out of the emotions. Additionally,
previous analyses indicated that sadness was identified better when the full-light walker was female.

7.3.2. Testing the Alarm Hypothesis in Full-light Walkers

7.3.2.1. Perceiver Ratings of the Intensity of the Emotion Displayed by Full-light Walkers

A 4 (displayed emotion) x 3 (intensity) x 2 (walker gender) Repeated Measures ANOVA was conducted to investigate whether perceiver ratings of the emotional intensity of full-light walkers were influenced by the specific emotion displayed by a walker, by the level of displayed emotional intensity and by the gender walker. The repeated measures analysis was chosen because there were roughly 36 combinations of each emotion at each level of intensity for both genders (36 actor walkers were recorded under 13 different conditions however, some conditions were missing for different actor walkers due to equipment malfunctions during recording. 423 walker stimuli were thus produced and shown to perceivers in this experiment, see section 7.2.2. for further details). Therefore each perceiver rated each combination of variables roughly 36 times thus requiring a repeated measures design. It should also be noted that only perceiver ratings from correct identifications (i.e. displayed emotion = perceived emotion) were used in this analysis. The inclusion of perceiver ratings from incorrect identifications could possibly warp the results of this statistical analysis in a way that would be uninformative for the purposes of this research. In an effort to reduce the high degrees of freedom (16050), the average correct rating for each perceiver for each cell of the design was used as the data scores thus each cell had 38 observations producing substantially lower degrees of freedom (888). However, one participant failed to make a correct identification in
one of the conditions thus that cell had a missing score. All scores for this single participant were therefore deleted from the analysis thus each cell had 37 observations further lowering the degrees of freedom (864). It should also be noted that neutral was dropped from this statistical analysis because neutral only has a single level of displayed intensity and was consequently only able to be rated by perceivers as expressing an intensity level of ‘5’ (i.e. most intense score, see section 7.2.2. for more details). Outliers were identified in multiple cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of covariance was not met for the main effect of displayed emotion and for the separate interactions for displayed emotion with intensity and also with walker gender. The Greenhouse-Geisser adjustment to the degrees of freedom was used for all effects and interactions where the assumption of homogeneity of covariance was not satisfied. The rest of the assumptions of the ANOVA were deemed satisfactory.

With alpha set at .05 all three main effects were found to be significant: Displayed emotion, $F(2.39, 85.99) = 19.76$, $p < .001$, partial $\eta^2 = .35$, obs. power = 1.00; intensity, $F(2, 72) = 329.08$, $p < .001$, partial $\eta^2 = .90$, obs. power = 1.00; walker gender, $F(1, 36) = 170.80$, $p < .001$, partial $\eta^2 = .83$, obs. power = 1.00. There were also three significant interactions: displayed emotion by intensity, $F(4.22, 152.04) = 3.85$, $p < .001$, partial $\eta^2 = .10$, obs. power = 0.90; and displayed emotion by walker gender, $F(2.41, 86.83) = 9.29$, $p < .001$, partial $\eta^2 = .21$, obs. power = 0.99; and displayed emotion by intensity by walker gender, $F(6, 216) = 4.00$, $p < .001$, partial $\eta^2 = .10$, obs. power = 0.97. Despite all the reported main effects and interactions being highly significant and having high power, the effect
sizes were relatively small, except for the main effects for intensity and walker gender. This indicates that the mean differences were not that large but the large sample size may have inflated both the significance levels and the observed power. Descriptive statistics are shown in Figure 7.8.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on how the data may relate to the hypothesised pattern of results (i.e. the alarm hypothesis, Walk & Homan, 1984). Thus the remaining 19 relevant post-hoc comparisons are described here. It should be noted that the intention of these analyses were to see how each identified emotion was rated by perceivers relative to other identified emotions of the same level of displayed intensity. Therefore, none of the reported post-hoc comparisons contrasted across different displayed intensity levels. All assumptions for the paired sample t-tests were deemed satisfactory. Only eight of these post-hoc comparisons reached significance. Sad female walkers at high intensity were rated significantly lower than angry female walkers at high intensity, \( t(37) = 5.14, p < .001 \). Fearful female walkers were rated significantly higher than fearful male walkers at low, \( t(37) = 5.34, p < .001 \); and high intensity, \( t(37) = 6.55 \). Angry female walkers were rated significantly higher than angry male walkers for low intensity, \( t(36) = 5.23, p < .001 \); moderate intensity, \( t(37) = 6.71, p < .001 \); and at high intensity, \( t(37) = 6.73, p < .001 \). Anger was rated as significantly lower than fear in male walkers at moderate intensity, \( t(37) = 6.07, p < .001 \). It should be noted that since the perceiver ratings used in this analysis were only from correct categorisations, a lower rating indicates a greater attunement to the
a) Female Walkers

![Graph showing mean correct perceiver ratings of emotional intensity for female walkers]

b) Male Walkers

![Graph showing mean correct perceiver ratings of emotional intensity for male walkers]

Figure 7.8. Mean correct perceiver ratings of emotional intensity for the specific emotions at each level of displayed intensity for a) female and b) male full-light walkers. Error bars depict 95% confidence intervals.
perception of that emotion (i.e. the emotion does not need to be perceived as intense in order to be accurately perceived). The results therefore suggest that perceivers are most attuned to the perception of high intensity sadness compared to other high intensity emotions but only in female walkers. The results also indicate that perceivers are more attuned to the perception of both anger and fear in male walkers compared to female walkers. Furthermore, the results indicate a greater perceptual attunement to anger than fear in male walkers at a moderate level of displayed intensity.

7.3.2.2. Reaction Times for the Perception of Emotions in Full-light Walkers

A 5 (displayed emotion) x 2 (gender) x 2 (accuracy) repeated measures ANOVA was conducted looking at the perceiver reaction times. The limitation of including neutral in the previous analysis (i.e. only a single level of intensity, see section 7.3.2.1.) is no longer valid therefore neutral emotion is included in this analysis. The previous analysis also only investigated correct categorisations made by perceivers. The current analysis is being conducted partly due to the need to verify the results of the previous analysis therefore in order to make a valid comparison correct categorisations will be used in the current analysis. However, the hypothesised relation of reaction time to the errors made in the categorisations of anger and fear warrants the need to also investigate incorrect categorisations made by perceivers. Thus the independent variable of accuracy (i.e. correct vs. incorrect) is also included in this analysis. Due to the nature of the accuracy variable some perceivers got all their categorisations for a particular cell either correct or incorrect, thus some cells had missing scores. To eliminate the missing scores from the repeated measures design four perceivers had their scores eliminated from each cell.
of the analysis thus there were 34 scores in each cell. The mean reaction times for each perceiver for each cell of the design were used as the data scores for this analysis in order to reduce the high degrees of freedom. Outliers were identified in several cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of covariance was not met for any of the main effects or interactions thus the Greenhouse-Geisser adjustment to the degrees of freedom was used for all main effects and interactions. The rest of the assumptions of the ANOVA were deemed satisfactory.

With alpha set at .05 all three main effects were found to be significant: Displayed emotion, \( F(2.57, 84.64) = 32.16, p < .001, \) partial \( \eta^2 = .49, \) obs. power = 1.00; gender, \( F(1, 33) = 4.47, p = .04, \) partial \( \eta^2 = .12, \) obs. power = .54; and accuracy, \( F(1, 33) = 95.19, p < .001, \) partial \( \eta^2 = .74, \) obs. power = 1.00. All two way interactions were also found to be significant: Displayed emotion by gender, \( F(2.89, 95.49) = 4.69, p = .01, \) partial \( \eta^2 = .12, \) obs. power = .88; displayed emotion by accuracy, \( F(2.49, 82.11) = 18.61, p < .001, \) partial \( \eta^2 = .36, \) obs. power = .100; and gender by accuracy, \( F(1, 33) = 18.11, p < .001, \) partial \( \eta^2 = .35, \) obs. power = .99. The three way interaction was not significant, \( F(2.98, 98.37) = 1.73, p = .17, \) partial \( \eta^2 = .05, \) obs. power = .44. Descriptive statistics are shown in Figure 7.9.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on whether the alarm hypothesis (Walk & Homan, 1984) could explain the
Figure 7.9. Mean reaction times (ms) for the a) correct and b) incorrect categorisations of the specific emotions for male and female full-light walkers. Error bars depict 95% confidence intervals.

...pattern of results and therefore make sense of the inconsistency in the results from the previous analyses. Thus the remaining 10 relevant post-hoc comparisons are
described here. All assumptions for the paired sample t-tests were deemed satisfactory. Only seven of these post-hoc comparisons reached significance. Anger was correctly identified significantly faster than fear in both male, \( t(37) = 4.99, p < .05 \); and female walkers, \( t(37) = 4.00, p < .05 \). Anger was categorised significantly faster for correct categorisations than incorrect categorisations for both male, \( t(37) = 5.71, p < .05 \); and female walkers, \( t(37) = 9.50, p < .05 \). Fear was also categorised significantly faster for correct categorisations than for incorrect categorisations for both male, \( t(37) = 4.80, p < .05 \); and for female walkers, \( t(37) = 7.71, p < .05 \). Correctly identified fear was identified significantly faster in female walkers compared to male walkers, \( t(37) = 4.49, p < .05 \). However, there was no significant difference in the reaction times for perceiving anger correctly between male and female walkers, \( t(37) = 2.02, p > .05 \). There was also no significant difference between correct and incorrect categorisations of neutral for both male, \( t(34) = 1.56, p > .05 \); and female walkers, \( t(33) = .247, p > .05 \).

The descriptive statistics shown in Figure 7.9 suggest a consistent pattern in the reaction time data: specifically, happy and angry walkers were identified faster than sad or fearful walkers. The perceiver’s reported identification strategies (reported later in section 7.3.3.) suggest that happy and angry walkers walked with a faster pace than sad and possibly fearful walkers. The combination of these results highlights a possible methodological confound of this experiment: video duration. The full-light walkers walked at varying paces across the predetermined walking space (see section 6.2.4); consequently creating video clips of differing duration. Furthermore, the Alvin program (version 1.19, Hillenbrand & Gayvert, 2005) recorded the perceiver reaction time from the beginning of the full-light walker
video display. Despite the perceivers being told to make their judgements as quickly as possible and that they did not need to wait until the end of the video clip to make their choice, it is feasible to consider that the perceivers waited until they viewed the maximum amount of walker information (i.e. end of video clip) before making their emotion categorization. It is therefore likely that happy and angry walkers were identified faster than sad and fearful walker because of the shorter duration of the full-light walker video clip. We therefore conducted four additional sets of analyses. Firstly, to verify that happy and angry walkers were indeed identified faster than sad and fearful walkers, we conducted a series of paired-sample t-tests comparing the identification times for each displayed emotion against each other displayed emotion. These analyses were conducted separately for both walker genders. Secondly, for comparative data, we analysed how the duration of the full-light walker video clips differed for each displayed emotion. Thirdly, we conducted a correlation to investigate the relationship between the duration of the full-light walker clips and the perceiver identification times. Lastly, we conducted a correlation on whether there was a relationship between the frequency of identifications for each emotion and the duration of the full-light walker video clips depicting those same emotions.

Our earlier analysis of the perceiver identification reaction time data was aimed specifically to test the alarm hypothesis (Walk & Homan, 1984). However, to discount this possible methodological confound of our experiment, we were required to conduct the first of our additional analyses. In our earlier analysis we already found that anger was identified faster than fear in both male, \( t(37) = 4.99, p < .05 \); and female walkers, \( t(37) = 4.00, p < .05 \). Therefore those comparisons did not need
to be included in the additional analyses. All other displayed emotion comparisons (not including neutral) were made separately for both walker genders thus 10 paired sample t-tests were conducted using the Tukey correction for multiple comparisons. Happiness was identified faster than sadness for both male, \( t(37) = 5.36, p < .05 \); and female walkers, \( t(37) = 6.47, p < .05 \). Happiness was also identified faster than fear for male walkers, \( t(37) = 4.80, p < .05 \); but not for female walkers, \( t(37) = 3.53, p > .05 \). Anger was also identified faster than sadness for both male, \( t(37) = 5.13, p < .05 \); and female walkers, \( t(37) = 6.04, p < .05 \). Fear was identified faster than sadness in female walkers, \( t(37) = 5.12, p < .05 \); but not male walkers, \( t(37) = 1.04, p = .307 \). There was also no significant difference in the perceiver identification times between happy and anger for both male, \( t(37) = .22, p > .05 \); and female walkers, \( t(37) = 1.37, p > .05 \). Happy and angry walkers were identified faster than sad and fearful walkers.

Our second additional analysis investigated whether the full-light walker video clips differed in duration between the emotions. The duration of each video clip constituted the dependant variable. Outliers were identified in several cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of variance was not met thus the nonparametric Kruskal-Wallis test was conducted. The Kruskal-Wallis was significant, \( \chi^2(4, N = 423) = 136.31, p < .001 \). All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to understand how the full-light walker video clip duration differed for each displayed emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. Only six of these post-hoc
comparisons reached significance. Sad walker video clips were of significantly longer duration than happy, \( z(N = 201) = 9.46, p < .001 \); angry, \( z(N = 192) = 9.04, p < .001 \); and neutral video clips, \( z(N = 134) = 5.67, p < .001 \). Fearful walker video clips were also of significantly longer duration than happy, \( z(N = 196) = 6.43, p < .001 \); angry, \( z(N = 187) = 6.59, p < .001 \); and neutral video clips, \( z(N = 129) = 3.48, p = .001 \). However, there was no significant difference between the duration of happy walker videos and that of angry, \( z(N = 195) = 1.11, p = .027 \); nor neutral walker video clips, \( z(N = 137) = 2.26, p = .024 \). Nor was there a difference between the duration of angry and neutral walker video clips, \( z(N = 128) = 2.76, p = .006 \). There was also no significant difference between the duration of sad walker and fearful walker video clips, \( z(N = 193) = 1.32, p = .189 \). Descriptive statistics are shown in Figure 7.10.

Because our video duration analysis results largely mirrored the emotion identification time data, we conducted a correlation between the duration of each video clip and the perceiver identification times for that clip. The data indicated some heteroscedasticity thus the nonparametric Spearman rho correlation coefficient was used with an alpha of .05. All other assumptions were satisfied. A significant positive correlation was found, \( \rho(421) = .616, p < .001 \), indicating that a longer full-light walker video clip was associated with increased perceiver identification times for the displayed emotions.

Our last additional analysis investigated whether the video duration influenced how often they identified a particular emotion by correlating the duration of each full-light walker video clip and the frequency of identifications for that clip across
all perceivers. The data indicated some heteroscedasticity thus the nonparametric Spearman rho correlation coefficient was used with an alpha of .05.

All other assumptions were satisfied. A small positive but significant correlation was found, $\rho(421) = .181, p < .001$, indicating that a longer walker video clip was associated with an increased identification of the emotion displayed by the walker. However, the correlation is weak enough to be considered negligible thus we can conclude that the duration of the walker video clips did not explain the perceiver identification differences between the different displayed emotions.

7.3.3. Most Commonly Reported Strategies for Identifying Emotions in Full-light Walkers
This section will report the most pertinent types of movements that perceivers reported to use to identify the specific emotions. For each emotion two or three movements were consistently reported by perceivers to identify specific emotions and thus only the three most frequently reported strategies will be described. The alternative strategies (i.e. other than the ones that will be described) were reported much less frequently by perceivers and thus are viewed as less reliable strategies to identify the specific emotions. Therefore this researcher does not believe that excluding the less reliably reported strategies will significantly reduce the quality of the results that will be described.

The perceiver identification strategies were coded by four separate researchers and a frequency tally was taken for each identification strategy. The mean frequencies (rounded to nearest integer) across the four coders will be described here. An intraclass correlation coefficient was calculated for each emotion as a measure of the degree of agreement between the four coders: Happy = .98; Sad = .99; Anger = .99; and Fear = .99.

7.3.3.1. Identification Strategies for Happy Full-light Walkers

A total of 125 separate comments (averaged across the four coders) were made by the perceivers regarding the strategies they reported to use to identify happiness in the full-light walkers. A total of 22 different movement strategies were reported to identify happy walkers but only the three most frequently reported movements will be described here. The most commonly reported strategy reported by perceivers to identify happiness in the walkers was ‘bouncy gait’ (27/125) which referred to the walker having a spring in their step as if the walker was dancing along. The second
most frequently reported strategy was ‘increased arm movement’ (26/125) which referred not only to a longer arm swing but often involved the arms swinging around and in front of the body. The next most frequently reported strategy was ‘head up’ (20/125) which referred to the walker looking forward in the direction they were travelling.

7.3.3.2. Identification Strategies for Sad Full-light Walkers

A total of 123 separate comments (averaged across the four coders) were made which was also divided into 17 separate strategies for identifying walkers displaying sadness. There were two separate strategies that were reported much more frequently than any other strategies. The most frequently reported strategy was ‘head down’ (37/123) which referred to when the walker looked at the ground or their own feet as they walked. The second most frequently reported strategy was ‘walk slower’ (34/123) which referred to a much slower walking pace by walkers identified as sad. There was a substantial drop-off before the next most frequently reported strategy, which was ‘shoulders slumped’ (8/123) which referred to the walker dropping their whole body towards the ground as if they didn’t have the strength to hold themselves upright.

7.3.3.3. Identification Strategies for Angry Full-light Walkers

A total of 139 comments (averaged across the four coders) were made which were divided into 20 separate strategies that perceivers reported to use to identify anger in the full-light walkers. The most frequently strategy reported by perceivers was ‘walk faster’ (31/139) which referred to angry walkers being perceived as
walking at a much faster pace than usual. The next most frequently reported strategy was ‘hands clenched’ (25/139) which involved the walker making fists as they walked. The next most frequently reported strategy was ‘stomping’ (24/139) which involved the walker raising their feet higher and hitting the ground with more force than is usually found in the typical rolling gait.

7.3.3.4. Identification Strategies for Fearful Full-light Walkers

A total of 127 comments (averaged across the four coders) were made which were divided into 17 separate strategies that perceivers reported to identify fear in the full-light walkers. The most frequently reported strategy by perceivers to identify fear in the walkers was ‘head looking around’ (36/127) which referred to the walker either looking from side to side or behind them as they walked. The next most frequently reported strategy was ‘faster walk’ (23/127) which referred to the walker’s increased walking speed. The next most frequently reported strategy was ‘slower walk’ (16/127) which referred to the walker’s decreasing walking speed.

7.4. Discussion

The support, or lack thereof, of each of the experimental hypotheses is abbreviated in Table 7.7 and will be discussed in the relevant section. Most notable are the five hypotheses that were supported in this experiment. Specifically: a) Perceivers reliably identified significantly above chance each specific emotion displayed by the full-light walkers. b) Sadness and Fear were identified significantly more than happiness and anger in female full-light walkers. c) Happiness was identified significantly more when displayed by female full-light walkers than when displayed by male full-light walkers. d) Fear was identified significantly faster in
female full-light walkers than in male full-light walkers. e) Happy and angry walkers were identified faster than sad and fearful walkers. All other hypotheses were not supported in this experiment.

Table 7.7
The Result of Each of the Full-light Walker Experimental Hypotheses

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesisa,b</th>
<th>Resultc,d</th>
</tr>
</thead>
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<tr>
<td>Identification Rates</td>
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</tr>
<tr>
<td></td>
<td>Male: Happy and Anger &gt; Sad and Fear</td>
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</tr>
<tr>
<td></td>
<td>Female: Sad and Fear &gt; Happy and Anger</td>
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<td>Male: Anger &gt; All other Emotions</td>
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<tr>
<td></td>
<td>Male Anger &gt; Female Anger</td>
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<tr>
<td></td>
<td>Female: Happy &gt; All other Emotions</td>
<td>x</td>
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<tr>
<td></td>
<td>Female Happy &gt; Male Happy</td>
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</tr>
<tr>
<td>Identified Emotion</td>
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<td></td>
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<td></td>
<td>Fear &lt; Happy and Sad</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>Anger &gt; All other Emotions</td>
<td>x</td>
</tr>
</tbody>
</table>

Note. Some of these hypotheses may appear contradictory because they are derived from opposing arguments or evidence. 

a<>/b denotes the direction of the specific hypothesis. Any expression preceding ‘:’ pertains to a specific condition applicable to that hypothesis. c✓ denotes a supported hypothesis. dx denotes an unsupported hypothesis.

7.4.1. The Identification of Specific Emotions

It was hypothesised that perceivers would reliably identify above chance the specific emotion that a walker is displaying through their walking style. As can be
seen from Table 7.2, the largest number of perceived emotion categorisations in each distribution is congruent with the emotion displayed by the walker. Furthermore, this effect was found for both male and female walkers (Table 7.3). Additionally, each emotion was identified significantly above chance for both male and female walkers, even after the conversion of perceiver scores to Hμ scores and calculating the adjusted chance scores for each cell of the design (Table 7.6). The findings therefore support the hypothesis that perceivers can reliably identify the specific emotion that a walker is displaying through their walking style. This finding is congruent with other research that have found that emotions can be perceived through bodily movement (Dittrich et al., 1996; Pollick et al., 2001) and in particular walking style (Michalak et al., 2009; Montepare et al., 1987; Troje, http://www.biomotionlab.ca/Demos/BMLwalker.html).

Montepare et al. (1987) found that the specific emotions happiness, sadness, anger and pride could be accurately identified from walking style by perceivers. Michalak (2009) also found that happy and sad walkers differed in their walking kinematics. Also, Troje’s website (http://www.biomotionlab.ca/Demos/BMLwalker.html) only shows the walking kinematics associated with happy and sad walkers. Thus the findings of the current study that fear can also be reliably identified from walking style extends the current literature to include the emotion fear in the set of emotions that can be perceived and expressed through walking style. Furthermore, Montepare et al. (1987) only used female walkers in their study and the current study had a roughly equal gender representation thus Montepare, at al.’s results can be generalised to the male population, albeit with some amendments (will be discussed later in this section).
We can now ask: Are the results of the current study a true representation of how specific emotions (i.e. happiness, sadness, anger and fear) are expressed through walking style or of how these emotions can be perceived through walking style or both?

The ecological theory of visual perception (Gibson, 1979/1986) argues that perception is largely veridical because “perception is for doing” (p143). That is, individuals have adapted and attuned their perceptual systems over their lives and through past generations to enhance the perception of environmental stimuli that are important for meeting that individual’s goals. This line of reasoning provides support for the validation of the stimuli that was used in this experiment. The stimuli were created by asking actors to display specific emotions through their walking style (see section 6.1.). As previously discussed, a pitfall of using this method for creating stimuli for emotion perception experiments is that it rests on the assumption that actors can successfully display the different emotions through their walking style instead of merely reproducing movements that the actors mistakenly believe display specific emotions. Since perceivers did reliably perceive the emotions displayed by the actor walkers, we can deduce that the actors were successful in their display of specific emotions through their walking style and thus validating the stimuli used in the experiment.

However, the previous argument for validating the emotional walker stimuli used in this experiment falls victim to the same logical fallacy that we have previously criticised Heberlein et al. (2004) for (see section 3.3.): the logic is circular. We know that the stimuli created in chapter 6 are valid because perceivers
can reliably identify the emotions that the walkers are intending to display and we can draw theoretical inferences from the perception based results because the walkers are assumed to successfully display the emotions. Whilst there is no way that we can fully break this circular reasoning, we can assume that both the actors successfully displayed the specific emotions and that perceivers accurately identified these same emotions based on two arguments: 1) The first of which is that the ecological theory of visual perception (Gibson, 1979/1986) explicitly argues that the perceptual systems are largely veridical and thus if perception is congruent with the production of emotion specific gait (as they are in this study) then we can conclude that both the production and perception of specific emotions in walking style are valid sources of information about how specific emotions are expressed through walking style. This argument is further supported by the finding in the stimulus construction part of this research that the vast majority of actors, who reported the acting method they used to convey specific emotions, used the Stanislavski method (see section 6.3.1.). Therefore the actor walkers tried to feel the emotions they displayed through their walking style and thus the stimuli used in this study is further validated due to the greater applicability of ecological theory (Gibson, 1979/1986). 2) The second argument loads on the logic of the first; the displayed emotions were accurately perceived by the observers with such reliability that accurate categorisations were consistently far above chance levels (see Table 7.6). Thus if the actor walkers did not successfully display specific emotions through their walking style the perceivers could not have attained such reliable results. Therefore, in accordance with the ecological theory of visual perception (Gibson, 1979/1986) the attempts by actors to successfully display specific emotions through their walking style and the ability of perceivers to perceive the displayed emotions act as
corroborative evidence that both the stimuli used are valid and theoretical inferences can therefore be made from the results of this study.

Congruent with the ecological perspective, the alarm hypothesis (Walk & Homan, 1984) states that individuals will perceive anger, followed by fear, better than any other emotions because they afford danger to that individual. An angry person may attack and thus it is important to perceive anger in a person’s movements. A person who is perceived as displaying fear is apparently in danger, though in less danger than when perceiving an angry person, and thus the perceiver may also be in danger through the close proximity with the fearful person. The perception of anger and fear in others is considered more important for our immediate survival thus our perceptual systems have adapted and attuned to perceive these emotions better than all other emotions. However, the results did not support the alarm hypothesis. The application of the alarm hypothesis to the pattern of identification rates shown in Table 7.6 will now be briefly discussed but the alarm hypothesis will be investigated with greater scrutiny in the next section (section 7.4.2.).

Angry walkers elicited the relatively poorest accurate identification rates compared to the other displayed emotions (except for neutral walkers), which is the reverse to what the alarm hypothesis predicted (Walk & Homan, 1984). Nevertheless fear was the emotion that was identified most accurately by perceivers in both walker genders. This finding gives partial support for the alarm hypothesis (Walk & Homan, 1984) though the evidence supports an offensive based alarm hypothesis whereby it is important to identify fear in others because of the potential
to take advantage of the perceived afraid walker. If the dominant affordance for perceiving fear in others was to alert the individual of potential environmental threats (Darwin, 1872/1999), as has been previously argued, then the identification rates of anger would have been comparable as the perception of anger also alerts to potential environmental threats. Anger was clearly not perceived as well as fear and thus the evidence from this study does not support this argument.

The previous argument is however, supported by Gunns et al. (2002), who argues that assaulters choose their victims by weighing up the risks and comparing them to the rewards for assaulting the individual. They found specific walking kinematics could convey the difference between an easy-to-attack target and a difficult-to-attack target. The perception of anger and fear in walkers appears to be congruent with their results. One would not wish to attack an angry person because they are more likely to fight back and thus the reward would be more likely to be denied. In contrast one would have a greater inclination to attack a fearful person because they are less likely to fight back and thus increasing the chances of the sought after reward. Therefore the evidence from this study supports the argument that perceivers are more sensitive to fear in walkers compared to anger and thus perceivers perceive the affordance of advantage over another person instead of the affordance of environmental danger.

The reader should not assume that the affordance of advantage over another person is directly related to attack or assault because of the examples used in the argument for an offensive based alarm hypothesis. An afraid person may be more
suggestible to comply with ones own wishes because of a reluctance to anger the person by challenging their wishes.

Alternatively, a person who is afraid may afford the need to be protected. Bowlby (1969) argues that adults have a predisposition to approach and protect babies. Perhaps this need to protect our fellow man is not restricted to infants but also extends to adults who are perceived to be in need of protection? This argument is supported by the finding that sad walkers, along with fearful walkers, were consistently perceived with accuracy better than all other emotions. In accordance with the ecological perspective (Gibson, 1979/1986), the perception of sadness in a walker may afford the opportunity to give assistance or to take advantage of the individual. The former affordance assumes that human beings are more altruistic and cooperative than is usually argued in ecological theory. However, the research on infants and supportive/protective behaviour gives credence to this possibility (Bowlby, 1969; Berry & McArthur, 1986). The perceived affordance is moderated by the goals and motivations of the perceiver. For example a person looking to rob someone may perceive the affordance of victim (Gunns et al., 2002) in a sad walker but a more co-operative person may perceive the affordance for assistance (Trivers, 1985).

A sad walker may appear as having a greater potential to be a victim than a fearful walker due to the lack of energy in sad movements compared to the nervous energy of a fearful walker which may cause the potential victim to escape through fleeing (Darwin, 1872/1999). The same argument may also explain why sad walkers had equivalent perceiver identification rates than fearful walkers (i.e. perceivers
perceived the affordance of assistance or victim). A fearful walker may be perceived as having the ability to flee because their movements indicate the readiness to retreat at a moment’s notice, whilst the lack of energy in a sad walker’s movements may be perceived as a total lack of ability to help themselves. Thus ecological theory can explain why sad and fearful walkers were perceived so well through understanding of the affordances involved in that perception.

We argue that the answer to why sadness was identified so well in the walkers is far simpler. Based on the general patterns of emotion specific gait that this researcher noticed in the stimulus construction part of this research (see section 6.3.2.) and Darwin’s (1872/1999) descriptions of how different emotions are expressed through bodily movements and facial expressions, happy, angry, and fearful walkers all had a higher degree of energy (e.g. fast pace) or tenseness (e.g. holding of hands) in their movements. Sadness in comparison lacked all sense of vitality or tension. The sad walkers were therefore likely to be identified by the greater comparison of slow lethargic movements of a sad walker to the energetic movements of happy and angry walkers and the tense movements of fearful walker. This argument is further supported by the results of the qualitative data collected from the perceivers about what strategies they reported to use to identify specific emotions in the full-light walkers (see section 7.3.3.).

Concerning theoretical explanations, the alarm hypothesis (Walk & Homan, 1984) predicts that anger, followed by fear, will be perceived more accurately than all other emotions (see section 2.2.1.) which again was not confirmed by the results of this experiment. However, as described in section 7.1. the full-light experiment
does not allow control (or randomisation) of several potential confounding factors (e.g. amount of fat or muscle in the body composition of the walker). Therefore, subsequent experiments will investigate whether this pattern of results is consistent across lighting conditions (i.e. full-light and point-light) and after the possible influence of structural cues have been eliminated (i.e. synthetic walkers).

Furthermore, each emotion (except fear) was identified better when the full-light walker was female than male. The hypothesis that female walkers would be perceived as displaying happiness more than male walkers was supported. This hypothesis was formulated on the premise that female specific gait would be somewhat similar to a happy gait which would afford co-operation to perceivers (see section 3.5.1.). Despite the support for this particular hypothesis, the finding that each of the emotions was identified better in female than male walkers suggests that the premise on which the hypothesis was founded may be in error. There is however, no guarantee that both male and female walkers displayed each emotion with equal skill. Grossman and Wood (1993) found that females experience and express more emotions than males, thus female actors likely were more proficient than male actors at displaying different emotions from walking style through increased practice. Increased proficiency by female actors at displaying various emotions would consequently increase the identification rates for those same emotions by perceivers.

The above reasoning could also explain why the additional hypothesis that male walkers would be perceived as displaying anger more than female walkers also was not supported. These findings are supported by the findings of Vaughn Becker et al. (2007) and Troje (2002) in that the gender specific body composition and
kinematics of the walker did influence the perception of happiness and anger in the full-light walkers.

It is however, not clear why happy walkers were misidentified as displaying neutral above chance in both male and female full-light walkers. It appears that the perception of happiness and the perception of neutral may be confused due to similar kinematics in their gait. Unfortunately the perceiver identification strategies were not collected for the neutral emotion thus preventing a direct comparison with the identification strategies for happiness. However, we can conjecture that perhaps a happy gait is perceived as relaxed and carefree and thus may be interpreted as a normal neutral gait. Alternatively, happiness may be perceived as the normal default state for walkers because it is a positive preferred emotion and thus perceived as neutral.

The previous discussion has briefly investigated how the present study’s results relate to the alarm hypothesis (Walk & Homan, 1984). The present study’s results so far have not provided support for the alarm hypothesis. However, the alarm hypothesis may find some support by delving deeper into the data and investigating the perceiver ratings and reaction times for the different emotions at each level of displayed intensity. We will therefore investigate and discuss the alarm hypothesis with greater scrutiny.

7.4.2. Testing the Alarm Hypothesis in Full-light Walkers

The perceiver identification rates have not supported the alarm hypothesis (Walk & Homan, 1984). However, perceiver ratings of emotional intensity and
emotion identification reaction times are more sensitive measures of emotion perception because they account for different degrees of emotion perception instead of the perceiver’s absolute ability to identify the displayed emotion. We therefore investigated the perceiver ratings of emotional intensity and emotion identification reaction times to get a clearer understanding of how the alarm hypothesis (Walk & Homan, 1984) influenced the perception of basic emotions from gait.

7.4.2.1. Perceiver Ratings of the Intensity of the Emotion Displayed by Full-light Walkers

 Whilst the identification rates discussed in the previous section (section 7.4.1.) did not provide much support for the alarm hypothesis (Walk & Homan, 1984), the alarm hypothesis may be supported by investigating the perceiver ratings of the expressed emotional intensity of each correctly identified walker in the current experiment. For example, the alarm hypothesis predicts that perceivers should be most attuned to the perception of emotions through bodily movement which are important for our survival (i.e. anger followed by fear), thus we can expect that anger followed by fear should be identified at a significantly lower level of perceived emotional intensity, thus receiving lower perceiver ratings, than the other emotions (i.e. happiness and sadness). That is, perceivers need less perceived emotional intensity to make a correct identification of the emotion displayed by a full-light walker. Whilst the alarm hypothesis does not make any explicit predictions regarding the gender of the perceived individual, we can make predictions based on ecological theory (Gibson, 1979/1986); anger will have significantly lower ratings of emotional intensity in male walkers, compared to female walkers, because the increased physical stature of males are more capable of harming an individual if they
are enraged. The flipside of the same argument would predict that fear will have significantly lower ratings of emotional intensity in female walkers, compared to male walkers, because their reduced physical stature would render females less capable of physically defending themselves.

The finding that perceivers are most attuned to the perception of sadness at high intensity but only for female walkers is not congruent with the hypothesised predictions provided by the alarm hypothesis (Walk & Homan, 1984). That is that perceivers will be most attuned to the perception of anger, followed by fear, because of their particular importance for our ecological survival. However, the current results are congruent with the results from the previously conducted data analysis on the identification of specific emotions (see section 7.3.1.). Sadness (with fear) was correctly identified by perceivers the best out of all emotions but particularly for female walkers. The same arguments previously made to explain why sadness was correctly identified better than the other emotions can therefore be applied to the current results (see section 7.4.1.). That is that perceivers are most attuned to the perception of sadness because of the affordance for potential opportunity for victimisation (Gunns et al., 2002) or for assistance (Trivers, 1985). The current results can also be explained by the alternative argument (also made in section 7.4.1.); the lethargic movements of sadness is in a greater comparison to the energetic movements of the other emotions and thus easier to identify. Therefore as the intensity of emotional display increases the difference between the lethargic movements of sadness and the energetic movements of the other emotions become greater. Thus sadness can be identified at a much lower perceived intensity compared to the other emotions and this is most evident when sadness is displayed
at high intensity where the difference is greatest. But why is this pattern only found for female walkers?

It was found in the previously conducted data analysis (see section 7.3.1.) that each emotion was identified better when the walker was female. The current finding that perceivers were most attuned to the perception of sadness, compared to the other emotions, at high intensity in female walkers is congruent with the results from the previously conducted data analysis. The previous arguments made can thus be applied to the current results. That is that females are more experienced and practiced at expressing their emotions (Grossman & Wood, 1993; Plant et al., 2000) and thus females are better skilled at displaying their emotions through walking style. Perceivers can therefore perceive the emotions displayed by females easier than emotions displayed by males. When this argument is coupled with the arguments explaining why sadness is perceived so well in walking style (see previous paragraph), a feasible explanation can be made as to why perceivers are most attuned to the perception of sadness at high intensity in female walkers.

However, the argument that females are more skilled at expressing their emotions (Grossman & Wood, 1993; Plant et al., 2000) and thus easier to perceive, does not explain why perceivers are more attuned to the perception of anger and fear in male walkers, as opposed to female walkers. It was hypothesised in this experiment that perceivers would be more attuned to the perception of anger in males because an angry male, due to their increased stature, is capable of accomplishing more physical harm upon the perceiver than an angry female. This hypothesis was supported in the current experiment. However, the linked hypothesis
that perceivers would be more attuned to the perception of fear in female walkers because females, due to their reduced stature, are less able to defend themselves against attack was not supported.

Perceivers were more attuned to both anger and fear when the walkers were male. This result could possibly be explained by the argument that males are more likely to respond to a threatening situation with a fight-or-flight response (Trivers, 1985) as opposed to the tend-and-befriend approach typically adopted by females (Taylor et al., 2000). Males are therefore more likely to be in a situation where they either fight with anger or flee out of fear. Previous exposure in the ecological environment of males fighting and fleeing from each other and other predators would allow perceivers to attune their perceptual systems to perceive both anger and fear better in males (Gibson, 1979/1986). Such reasoning can thus explain why perceivers are more attuned to the perception of both anger and fear in male walkers.

Therefore there is partial support for the alarm hypothesis (Walk & Homan, 1984) from the results of this experiment. Perceivers were particularly attuned to the perception of both anger and fear but only in male walkers. However, anger and fear were not correctly identified more in male walkers than female walkers (see section 7.3.2.). One possible explanation for this result is that perceivers are more attuned to the perception of anger and fear in male walkers and thus the perceivers are primed towards action instead of conscious awareness (Eastwood et al., 2003). The reaction times that perceivers required to categorise the emotion displayed by full-light walkers may enlighten to why perceivers appear to be more attuned to the perception
of anger and fear in male walkers even though they were not correctly identified significantly more than the other emotions and in female walkers.

7.4.2.2. Reaction Times for the Perception of Emotions in Full-light Walkers

As argued in the alarm hypothesis (Walk & Homan, 1984) the perception of anger, followed by fear, is important for an individual’s survival. The perception of anger or fear in another individual would thus require much faster reactions than does the perception of sadness or happiness in another person. Any mistaken perceptions of an angry or a fearful individual would likely hold greater consequences than a mistaken perception of a sad or happy individual. Mistakenly perceiving the emotional state of an angry person could cause the perceiver to stay in the angry person’s presence and thus more likely to come to harm. Alternatively mistakenly perceiving a fearful person could cause the perceiver to miss the opportunity to fight or chase off their opponent. However, the missed opportunity of mistakenly perceiving a fearful person will not have as drastic consequences as mistakenly perceiving an angry person because an angry person is more likely to attack than a fearful person. Perceivers thus were hypothesised to categorise angry, followed by fearful walkers, faster because their bodies and minds are diverting their resources towards action (i.e. clicking a categorical button) instead of conscious awareness (i.e. basing their categorisations off a well thought about strategy). This hypothesis was not supported in this experiment.

However, the very same argument can be made to explain why perceivers may be slower at identifying angry and fearful walkers. The diversion of cognitive and bodily resources to action may not cause perceivers to make pre-emptive
categorisations. Perceivers may restrain from making a categorisation until enough

cognitive resources have been salvaged for the perceiver to consciously decide

which emotion the walker is displaying. Thus the opposite hypothesis that anger,

followed by fear, would be identified the slowest out of the five emotions was made.

However, this alternative hypothesis also was not supported.

The finding that perceivers were faster in making correct categorisations than

incorrect categorisations for anger and fear and in both male and female walkers

supports the assumption of this experiment that perceivers took longer to make
difficult decisions compared to easy decisions. That is, perceivers waited before

making a decision until they had enough perceptual information on which to base a
decision about which emotion the full-light walker was displaying. Furthermore, the

lack of significant difference in perceiver reaction time between correct and

incorrect categorisations for neutral emotion lends support to the explanation that

neutral categorisations were a default choice for perceivers. That is when perceivers

perceived no evident emotion in the full-light walkers they chose neutral. This

argument supports the major claim in this research that specific emotions can be

perceived through walking style and that if no emotion is perceived then likely no

emotion is displayed.

Additionally, there was a significant difference in the time it took for

perceivers to categorise the emotion displayed in male walkers compared to female

walkers. Perceivers correctly identified fear in female walkers faster than male

walkers. This result may be due to females experiencing and thus expressing fear

more than men (Grossman & Wood, 1993; Plant et al., 2000). Females, due to their
reduced stature, are physically less able to defend themselves from assault than males. Therefore it is reasonable to assume that females are also more susceptible to experiencing fear. Congruent with ecological theory (Gibson, 1979/1986), our perceptual systems would thus have had ample exposure to attune to the perception of fear more so in females than males.

The same argument predicted that anger would be perceived faster in male walkers than female walkers. The latter prediction was not supported. It was found in earlier analyses that female walkers had higher correct categorisation rates than male walkers (see section 7.3.1.). It was argued that specific emotions were identified better in female walkers than male walkers because females were better at expressing their emotions due to greater experience. Perhaps the greater ability of female walkers in expressing all of their emotions (Grossman & Wood, 1993; Plant et al., 2000) counteracted the increased likelihood of perceiving anger in male walkers. Female walkers thus being better displayers of emotions through walking style could be identified faster than male walkers. However, due to the greater ecological importance of perceiving anger in males, angry male walkers were perceived significantly faster than fearful male walkers. A combination of these two explanations could therefore explain the lack of significance between the time it took perceivers to accurately identify anger in male and female walkers. However, this explanation does not explain why happiness was identified just as fast as anger in both male and female walkers.

The ecological perspective (Gibson, 1979/1986) provides several possible explanations for why anger and happiness had comparable reaction times for correct
identifications and why they were identified faster than either sad or fearful walkers.
The first of which is that in the ecological environment walking is typically the
movement that is used to approach or withdraw from someone/something. The
circumplex model used in this research thus used the dimension of
approach/withdrawal to distinguish between the different emotions (Davidson et al.,
1990; Feldman Barret & Wager, 2006). Happiness and anger are both approach
emotions and sadness and fear are both withdrawal emotions. Perceivers need to
identify approach emotions faster because in the ecological environment perceivers
will have less time to perceive the emotion displayed by someone approaching them
than someone withdrawing from them. This effect is likely to be promoted when
perceiving the emotion displayed in a walker because walking is the method
typically used to either approach or withdraw from someone in the environment.
However, this explanation appears to be rudimentary and fails to account for the
previous results found in this experiment (i.e. correct identifications rates and
perceived intensity ratings). Alternative theoretical and methodological explanations
must therefore be explored to investigate which theory best accounts for the
resulting data.

The alarm hypothesis (Walk & Homan, 1984) argument would also explain
why anger had relatively low identification rates compared to the other emotions
(see section 7.3.1.). Perceivers may have made pre-emptive categorisations due to
the need to react quickly to an angry walker compared to walkers displaying other
emotions. Pre-emptive categorisations can therefore give rise to higher inaccurate
categorisations (i.e. false alarm rates) for anger than for the other emotions. The
current study’s finding that anger was categorised faster than either sadness or fear
would lend support to this explanation. However, the finding that happiness was perceived just as fast as anger and faster than fear would not support this explanation.

One such methodological explanation would argue that the length of the video clips of the full-light walkers may have influenced the measurement of the perceiver’s reaction times. Reaction time data was measured from the beginning of each video clip depicting the full-light walker walking to the time that perceivers made their categorisation of the emotion displayed by the walker. Perceivers were not required to wait until the end of the video clip to identify the emotion the full-light walker was displaying. However, it is not unreasonable to assume that perceivers often waited until the conclusion of the video clip before making their choice. This assumption is supported by the finding that happy and angry walkers were categorised correctly and incorrectly by perceivers faster than sad or fearful walkers. However, the recordings of the full-light walkers depicted each walker walking across a predetermined distance (i.e. the Vicon Nexus calibrated space, see section 6.2.4.). As such a faster walk would cover that distance in less time and thus have a shorter video recording and a slow walk would cover that same distance in more time and thus have a longer video recording. A longer video clip would consequently have longer reaction time data and vice-versa.

However, this argument is contingent on evidence that full video recordings of walkers displaying happiness and anger were shorter in duration than recordings of sadness and fear. We found that the full-light walker videos depicting happiness and anger were indeed of shorter duration than the video clips depicting sadness and
fear. Furthermore, we found a significant positive correlation between the length of the video clips and the perceiver identifications times. It is thus reasonable to conclude that the duration of the full-light video clips depicting each of the specific emotions largely explains the perceiver reaction time results and is currently the best explanation for our results.

The results of the study so far have been inconsistent at best. Thus no strong theoretical conclusions can yet be made as to how best to explain this study’s resulting data. Therefore the self-reported strategies that perceivers used to identify the different emotions in full-light walkers may provide some much needed clarification to what theory best explains the resulting data of this study.

7.4.3. Most Commonly Reported Strategies for Identifying Emotions in Full-light Walkers

No explicit predictions were made about which specific gait movements perceivers would report to use to identify the different emotions in walking style. However, the results from the exploratory investigation will be discussed in relation to previous findings and theory.

7.4.3.1. Identification Strategies for Happy Walkers

Michalak et al. (2009), Montepare et al. (1987) and Troje (http://www.biomotionlab.ca/Demos/BMLwalker.html) found that happy walkers walked with a fast pace. Whilst perceivers in the present study did not predominantly claim to identify the walkers by faster pace, this was the fourth most used strategy for identifying happy walkers (9/125). It can be concluded that a fast
walking pace is relevant to the identification of happiness in walking style but there are alternative gait movements that inform more as to whether a walker is happy or experiencing some other emotion.

However, the prototypical happy walkers on Troje’s website (http://www.biomotionlab.ca/Demos/BMLwalker.html) were also characterised by a bouncier gait. This is congruent with the results of this study which found that the most commonly reported strategy that perceivers used to identify happy walkers was bouncy gait (27/126). There is additional support from Darwin (1872/1999) who described the expression of joy through “various purposeless movements – to dancing about” (p195), hence the idiom “jumping for joy”. Perceivers often described a bouncy gait as if the walker was dancing along and attributed this movement to happiness. We can therefore conclude that a bouncy walking style is a good indicator of a walker expressing happiness.

Furthermore, Michalak (2009) found that happy walkers, compared to sad walkers, exhibited more arm swing thus supporting the second most frequently reported strategy that perceivers used to identify happiness in walkers: ‘increased arm movement’ (28/124). Additionally, the “various purposeless movements” that Darwin (1872/1999, p195) attributed to joy could also be perceived from large arm movements. Darwin explained that joy is expressed due to pent up positive energy which can lead to energetic movements such as long arm swing and the swinging of the arms around the body. The swinging of the arms around the body, as opposed to just long arms swing, will cause more rotational force to be imbued into the gait. The resulting walk will not be as energy efficient in regards to moving from one
point to another. The lack of gait efficiency due to a supposedly purposeless movement (i.e. swinging arms around the body) could be perceived by perceivers as pent up energy with no immediate goal. Of the three energetic emotions (i.e. happy, anger, and fear) happiness is the only emotion which is not relevant to an immediate goal in the environment and thus large rotational arm swings could be attributed to happiness.

Michalak (2009) provides support for the third most frequently reported identification strategy for happiness in walkers (i.e. head held high), who found that happy walkers showed more vertical head movement than sad walkers. Darwin (1872/1999) also provides a further explanation with his description a person in high spirits, which can also be termed happiness, as expressing their cheerfulness by holding their “body erect, his head upright, and his eyes open” (p210). Happiness is often also described through the idiom “head held up high”. The congruence between the present studies results with Michalak’s (2009) findings and with Darwin’s (1872/1999) descriptions support the idea that happiness is identified in a walker when that walker holds their head erect and looks in the direction they are travelling.

7.4.3.2. Identification Strategies for Sad Walkers

Darwin (1872/1999) described the expression of sadness through passive movements due to flaccid unenergetic muscles. The lack of vitality is also found in the sad walkers of past research (Chouchourelou et al. 2006; Edgeworth, 2008; Michalak, 2009; Montepare et al., 1987; and Troje, http://www.biomotionlab.ca/Demos/BMLwalker.html), all of which had a slow
slouching gait with less arm movement. However, Edgeworth (2008) found that sad walkers did not differ in their joint movement throughout the gait cycle compared to speed-matched non-emotional walkers. Nevertheless, Edgeworth (2008) also found that sad walkers lowered their head significantly more than speed-matched non-emotional walkers which may accentuate the perceived slouching posture of sad gait. Each of the strategies that perceivers frequently used in the current study can be described as lacking in vitality. The current findings are therefore congruent with the past research. It appears that sadness is expressed and perceived through a slow lethargic walking style.

7.4.3.3. Identification Strategies for Angry Walkers

The strategy that perceivers most frequently reported to use to identify angry walkers was when the walkers walked faster. This strategy is also congruent with Darwin’s (1872/1999) description of an enraged man who expresses their anger through energetic approaching movements. Chouchourelou et al. (2006) also showed that anger was expressed through high velocity gait movements which are easy to detect, even within visual noise. Furthermore, Montepare et al. (1987) and Edgeworth et al. (2008) found that angry walkers walked with a longer stride which consequently increases the pace of the walker (Sutherland, 1994). Therefore faster walking pace appears to be a valid indicator of the expression and consequently perception of anger in a walker.

Both the second and third most frequently reported strategies used by perceivers to identify anger in the full-light walkers (i.e. ‘hands clenched’ and ‘stomping’ respectively) are congruent with Darwin’s (1872/1999) description of an enraged
man. Darwin explains that the angered mind gives strength to the muscles to prime the body to act immediately (e.g. to fight off a predator). The increased muscle strength results in strong forceful movements such as stomping the ground harder than usual or the clenching of fists (presumably ready to strike). Furthermore, Atkinson et al. (2004) found that anger could be accurately perceived when actors shook their fists and stamped the ground with their feet. Therefore it is not surprising that perceivers identified anger in full-light walkers through vitiating movements such as stomping and the clenching of fists.

7.4.3.4. Identification Strategies for Fearful Walkers

During the stimulus construction actor walkers generally displayed fear through their walking style by looking around as they walked (see section 6.3.2.). The most frequently reported strategy that perceivers used to identify fear in full-light walkers (i.e. ‘head looking around’) is congruent with what this researcher noticed during stimulus construction. Furthermore, there is additional support from Darwin (1872/1999) for this method of expressing and perceiving fear through walking style. Darwin explains that when a person experiences fear their visual and auditory senses are heightened, presumably to increase awareness of any potential danger in the environment. It is reasonable to assume that heightened perceptual awareness as a result of fear would result in the head turning as they walked in order to perceive any danger that may occur in the environment. It is therefore not surprising that the most frequently reported strategy that perceivers used to identify fear in full-light walkers involved the walkers turning their head to look around the surrounding environment.
There appears to be some confusion between what other strategies perceivers adopted to identify fear in full-light walkers (i.e. ‘faster walk’ and ‘slower walk’). Upon questioning the actors during stimulus construction about the acting strategy they adopted for displaying fear through their walking style, the actors responded by explaining that the selection for their gait movements were based on their individual interpretation of what they were supposed to be afraid of in the environment (see section 6.3.2.). For example if they interpreted the fearful stimulus in the environment as something to be fled from then they walked fast but if they interpreted the fearful stimulus as something to be cautious of then they walked slowly. It is reasonable to assume that perceivers were aware of the duality in fearful contexts and thus interpreted fear displaying walkers accordingly. If so, then it is not surprising that perceivers identified fear in full-light walkers through both fast and slow walking pace.

7.5. Conclusion

It has been shown that specific emotions can be accurately and reliably perceived through walking style. It has also been shown that sadness and fear were correctly identified the best out of all emotions investigated. Neutral emotion has been argued to be the default choice by perceivers for when no specific emotion can be identified in the full-light walker. It has also been argued that females are better at displaying different emotions and thus easier to be perceived through walking style. However, there is some contradictory evidence for this argument due to some possible ecological theoretical influences. Despite weak evidential support for the alarm hypothesis (Walk & Homan, 1984), the inconsistency in the results across analyses leads to the rejection of the alarm hypothesis. Emotion specific gait
movements have also be reported by perceivers for happiness, sadness, anger and fear.
Chapter 8

Experiment 2: Point-light Display of Walkers

Using point-light displays of walkers instead of full-light displays reduces the amount of visual information available to the perceivers. As previously discussed (section 2.1.) point-light displays reduce the stimuli to kinematic information (Johansson, 1973) though some structural information can still be perceived (Cutting et al. 1978). Additionally in the full-light experiment (see section 7.2.2.) all walkers were displayed approaching the perceiver. This may have created confusion among perceivers for the perception of withdrawal emotions (i.e. sadness and fear) in an approaching walker. To minimise this confusion, non-translating point-light walkers were shown to perceivers in the current experiment. This experiment will therefore investigate whether different emotions can be perceived through point-light displays of gait.

8.1. Introduction

There are few studies investigating the perception of different emotions from point-light displays of gait (Chouchourelou et al. 2006; Heberlein et al. 2004; Troje, http://www.biomotionlab.ca/Demos/BMLwalker.html). None of these studies specifically investigate the identification rates for different emotions as shown from point-light displays.

Heberlein et al. (2004) attempted to calculate a correctness score (i.e. identification rates) for the perception of different emotions from point-light walker movies for patients who were brain damaged in their ability to recognise emotions.
However, the correctness scores were only a representation of correct or incorrect identifications in comparison to how neurologically normal controls identified the point-light walker movies. A walker was categorised as displaying happiness if the majority of the neurologically normal controls perceived the point-light walker as displaying happiness. Heberlein et al. (2004) therefore did not investigate how well each emotion was identified but investigated how brain damaged patients categorise different emotions in comparison to neurologically normal controls.

Chouchourelou et al. (2006) did not intend to specifically investigate the identification rates for the different emotions from point-light walkers rather the link between the amygdala (a neural centre for emotional processing) and the visual detection of action. However, Chouchourelou et al. created a set of point-light walker movies that effectively communicated the specific emotions with >83% inter-rater reliability. Three point-light walker movies for each emotion (i.e. happy, sad, anger, fear and neutral) were subsequently chosen. Therefore we can conclude that these particular point-light walker movies effectively communicated the different emotions but no data were reported on the point-light walker movies that were not identified with high inter-rater reliability. Therefore it cannot be assessed how well the different emotions can be identified by perceivers from point-light walkers.

Of the studies that investigated the perception of specific emotions from point-light walkers, none have directly examined how well the specific emotions can be identified nor the difference in identification rates for different emotions between full-light walkers and point-light walkers. Troje and colleagues
(http://www.biomotionlab.ca/Demos/BMLwalker.html) have however, explored what gait movements are used by perceivers to identify happiness and sadness; and Chouchourelou et al. (2006) found that high velocity movements are important for the perception of anger from point-light displays. Additionally, Edgeworth et al. (2008) found anger was displayed by a high velocity walking style (i.e. increased cadence and stride length). However, no researcher has explored what gait movements are used by perceivers to identify fear in point-light walkers. Additionally no researcher has directly investigated the time required by perceivers to identify each specific emotion from point-light walkers. This experiment will therefore investigate the identification rates, reaction times and gait specific movements for the perception of each emotion from point-light walkers.

8.1.1. Research Questions

The three research questions investigated in this point-light experiment are identical to those in the full-light walker experiment. The only difference is that in this experiment the questions will relate to the impoverished stimuli of point-light display walkers. As a reminder the research questions are listed again here:

1) Can perceivers reliably identify the emotion that a walker is intending to express through their walking style?

2) Is the alarm hypothesis supported when perceiving different emotions through walking style?

3) Does the gender of the walker influence the perception of different emotions through their walking style?
The same independent variables (i.e. displayed emotion, accuracy, intensity, and gender) and dependent variables (i.e. perceived emotion, reaction time, and perceiver ratings) that were used in the full-light experiment will also be used in this experiment.

In this experiment, the presented stimuli have reduced the amount of available visual information to exclude some of the confounding variables that were present in the previous full-light experiment (e.g. bodily composition of the walker). Therefore, despite the lack of support for the majority of the hypotheses in the full-light experiment, the same hypotheses will be made in this experiment (abbreviated in Table 8.1). Specifically the following hypotheses were tested in this experiment: 1) Perceivers will reliably identify above chance the specific emotion that a walker is displaying through their walking style. 2) Male point-light walkers will be perceived as displaying significantly more approach emotions (i.e. happiness and anger) than withdrawal emotions (i.e. sadness and fear). 3) Female point-light walkers will be perceived as displaying significantly more withdrawal emotions (i.e. sadness and fear) than approach emotions (i.e. happiness and anger). 4) Male point-light walkers displaying anger will be identified significantly more than any other emotion displayed by male walkers. 5) Point-light walkers displaying anger will be identified by perceivers significantly more when the walker is male than when the walker is female. 6) Female point-light walkers displaying happiness will be identified significantly more than any other emotion displayed by female walkers. 7) Point-light walkers displaying happiness will be identified by perceivers significantly more when the walker is female than when the walker is male. 8) Perceivers will be able to accurately identify a lower intensity of displayed anger in point-light walkers
Table 8.1

*Abbreviations for Each Hypothesis for this Point-light Walker Experiment*

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis$^{a,b}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification Rates</td>
<td>Emotion &gt; Chance</td>
</tr>
<tr>
<td></td>
<td>Male: Happy and Anger &gt; Sad and Fear</td>
</tr>
<tr>
<td></td>
<td>Female: Sad and Fear &gt; Happy and Anger</td>
</tr>
<tr>
<td></td>
<td>Male: Anger &gt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Male Anger &gt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female: Happy &gt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Female Happy &gt; Male Happy</td>
</tr>
<tr>
<td>Identified Emotion</td>
<td></td>
</tr>
<tr>
<td>Intensity Ratings</td>
<td>Anger &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Fear &lt; Happy and Sad</td>
</tr>
<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td>Identification Times</td>
<td>Happy &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Anger &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td></td>
<td>Happy and Anger &lt; Sad and Fear</td>
</tr>
<tr>
<td></td>
<td>Anger &gt; All other Emotions</td>
</tr>
</tbody>
</table>

*Note.* Some of these hypotheses may appear contradictory because they are derived from opposing arguments or evidence. $^a$’denotes the direction of the specific hypothesis. $^b$Any expression preceding ‘.’ pertains to a specific condition applicable to that hypothesis.

than for all other emotions. 9) Perceivers will be able to accurately identify a lower intensity of displayed fear in point-light walkers than either happiness or sadness.

10) Perceivers will rate correctly identified angry point-light walkers as expressing a significantly lower level of intensity when the walker is male as compared to female.

11) Perceivers will rate correctly identified fearful point-light walkers as expressing a significantly lower level of intensity when the walker is female as compared to
male. 12) Happiness displayed through walking style will be identified significantly faster than all other emotions. 13) Anger will be identified significantly faster than all other emotions. 14) Anger will be identified significantly faster in male walkers than female walkers. 15) Fear will be identified significantly faster in female walkers than male walkers. 16) Negative emotions will be identified significantly slower than positive emotions. 17) Anger will be identified significantly slower than all other emotions.

Additionally, the data from this experiment will be used to further fine tune the stimuli that will be utilised in the following experiments (i.e. synthetic walkers).

8.2. Method

8.2.1. Participants

The sample of perceivers comprised 15 male and 19 female (N = 34) first year and postgraduate psychology students (from the University of Western Sydney). First year psychology students were given course credit for their participation in the experiment whilst all postgraduate students voluntarily participated. The sample had a mean age of 26.71 years (SD = 5.61). All perceivers had normal or corrected to normal vision. Informed consent was obtained from each perceiver (Appendix F).

8.2.2. Materials

The set of point-light walkers that was used as stimuli (Appendix G) were created from the gait recordings of the walkers recorded during stimulus creation. However, the measurement of each walker’s movements was restricted by the size of the Vicon capture volume which was smaller than what could be recorded with
the full video camera. Consequently, the duration of the constructed videos of the point-light walker stimuli were slightly shorter than that of the full-light walker stimuli. The kinematic data of the point-light walkers was imported from Vicon into Matlab (The MathWorks, Inc.). The individual points of the point-light walkers were the same as the points placed on the actor walker’s joints during stimulus creation (see Figure 6.1). Congruent with the previous description of full-light walkers, each trial of an actor walker will be described separately hereafter as a separate walker. A total of 409 walkers (happy = 93, sad = 101, anger = 100, fear = 84, neutral = 31) was shown to perceivers. A total of 59 walkers (happy = 15, sad = 7, anger = 8, fear = 24, neutral = 5) could not be shown to perceivers due to equipment malfunction during recording which consequently prohibited the transformation of the data into point-light displays of sufficient duration for the experiment. All displayed intensity levels were more or less equally represented for each emotion (range = 27-35).

The dots depicting the movements of each walker were difficult to distinguish when the walker was farther away thus depriving perceivers of potentially valuable gait information. The distinctiveness of each dot was preserved by keeping the size of the walker constant and creating non-translating point-light walkers. For every walker the common translatory component of each marker was subtracted by performing a principal components analysis (Jackson, 1991) in Matlab (The MathWorks, Inc.). The first principal component always represented the translation of the walker across the designated movement space. Therefore this component was excluded from a reconstruction of the data based on all remaining components thus creating non-translating walkers with the ecologically valid kinematics of a locomotive walker.
As with the full-light walker experiment, the experiment control software Alvin (version 1.19, Hillenbrand & Gayvert, 2005) that was used to display walkers and record perceiver responses was also used in this experiment. The program used was identical to that used in the full-light walker experiment with the exception that perceivers viewed non-translating point-light walkers instead of translating full-light walkers. Presentation of walkers displaying each emotion at each level of intensity was randomised. This was followed by a blank screen for two seconds, before moving onto the next point-light walker.

8.2.3. Design

The same design that was used in the full-light walker experiment was also used in this experiment. Despite the stimuli being reduced to point-light display, the gender of the walker might still be perceived (Troje, 2002). Accordingly, the independent variable of gender was not removed from this analysis.

8.2.4. Apparatus and Procedure were identical to that used in the full-light walker experiment.

8.3. Results

8.3.1. The Identification of Specific Emotions

As previously discussed (see section 7.3.1.), there is a need to control for repeated measures stimulus presentation and thus minimise observer response bias, inaccurate calculations of chance and the overestimation of perceiver performance. Wagner (1993) therefore suggested converting the raw frequency scores to $H_u$
scores and comparing \( H_u \) to a modified chance level (i.e. \( H_c \)) for each cell of the
design. The total converted \( H_u \) and \( H_c \) scores are shown in Table 8.2 and separated
by gender in Table 8.3. Happiness displayed by point-light walkers were identified
most accurately for both genders of walkers. Sadness was identified in both genders
the second best out of the emotions. Anger and fear was identified the 3\(^{rd}\) and 4\(^{th}\)
best however, the order is different for different genders. Anger was identified better
than fear when the point-light walker was female whilst fear was identified better
than anger when the point-light walker was male. Neutral was identified the poorest
out of the five emotions for both genders.

Table 8.2

*The Mean \( H_u \) Scores of Perceived Emotion Categorisations Compared to the
Displayed Emotion of Point-Light Walkers.*

<table>
<thead>
<tr>
<th>Perceived Emotion Category</th>
<th>Displayed Emotion Category</th>
<th>Happy</th>
<th>Sad</th>
<th>Anger</th>
<th>Fear</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td></td>
<td>.306 *</td>
<td>.014</td>
<td>.044</td>
<td>.003</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.049)</td>
<td>(.053)</td>
<td>(.052)</td>
<td>(.044)</td>
<td>(.016)</td>
</tr>
<tr>
<td>S</td>
<td></td>
<td>.002</td>
<td>.279 *</td>
<td>.009</td>
<td>.082 *</td>
<td>.004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.048)</td>
<td>(.053)</td>
<td>(.052)</td>
<td>(.044)</td>
<td>(.044)</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>.053 *</td>
<td>.006</td>
<td>.248 *</td>
<td>.008</td>
<td>.012</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.045)</td>
<td>(.049)</td>
<td>(.049)</td>
<td>(.041)</td>
<td>(.015)</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>.009</td>
<td>.011</td>
<td>.014</td>
<td>.273 *</td>
<td>.002</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.032)</td>
<td>(.035)</td>
<td>(.034)</td>
<td>(.029)</td>
<td>(.011)</td>
</tr>
<tr>
<td>N</td>
<td></td>
<td>.028</td>
<td>.088 *</td>
<td>.042</td>
<td>.026</td>
<td>.106 *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(.052)</td>
<td>(.057)</td>
<td>(.056)</td>
<td>(.047)</td>
<td>(.018)</td>
</tr>
</tbody>
</table>

*Note.* The mean \( H_c \) level for each cell is given in corresponding parentheses. * denotes a \( H_u \) score that is higher than the corresponding \( H_c \) score.
To investigate whether the correct emotion was identified five separate 5 (perceived emotion) x 2 (Hu vs. Hc) x 2 (gender) repeated measures ANOVAs were conducted for each displayed emotion. All Hu and Hc scores were arcsine transformed for each ANOVA and subsequent post-hoc analyses. Outliers were identified in multiple

Table 8.3

The Mean Hu Scores of Perceived Emotion Categorisations Compared to the Displayed Emotion of Point-Light Walkers Split by Gender.

<table>
<thead>
<tr>
<th></th>
<th>Displayed Emotion Category</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Happy</td>
<td>Sad</td>
<td>Anger</td>
<td>Fear</td>
<td>Neutral</td>
</tr>
<tr>
<td><strong>Female Point-light Walkers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>.312 * (.050)</td>
<td>.018 (.052)</td>
<td>.041 (.052)</td>
<td>.002 (.045)</td>
<td>.004 (.016)</td>
</tr>
<tr>
<td>S</td>
<td>.001 (.042)</td>
<td>.302 * (.046)</td>
<td>.002 (.046)</td>
<td>.063 * (.038)</td>
<td>.007 (.014)</td>
</tr>
<tr>
<td>Perceived Emotion Category A</td>
<td>.054 * (.051)</td>
<td>.004 (.055)</td>
<td>.298 * (.055)</td>
<td>.015 (.046)</td>
<td>.009 (.017)</td>
</tr>
<tr>
<td>F</td>
<td>.006 (.037)</td>
<td>.012 (.039)</td>
<td>.020 (.039)</td>
<td>.293 * (.033)</td>
<td>.004 (.012)</td>
</tr>
<tr>
<td>N</td>
<td>.028 (.047)</td>
<td>.094 * (.052)</td>
<td>.026 (.052)</td>
<td>.016 (.043)</td>
<td>.121 * (.016)</td>
</tr>
<tr>
<td><strong>Male Point-light Walkers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>.311 * (.047)</td>
<td>.009 (.052)</td>
<td>.045 (.051)</td>
<td>.003 (.043)</td>
<td>.013 (.016)</td>
</tr>
<tr>
<td>S</td>
<td>.003 (.055)</td>
<td>.264 * (.060)</td>
<td>.020 (.059)</td>
<td>.109 * (.050)</td>
<td>.003 (.019)</td>
</tr>
<tr>
<td>Perceived Emotion Category A</td>
<td>.054 * (.039)</td>
<td>.006 (.043)</td>
<td>.198 * (.042)</td>
<td>.003 (.036)</td>
<td>.017 * (.013)</td>
</tr>
<tr>
<td>F</td>
<td>.009 (.027)</td>
<td>.010 (.030)</td>
<td>.009 (.029)</td>
<td>.263 * (.025)</td>
<td>.001 (009)</td>
</tr>
<tr>
<td>N</td>
<td>.026 (.054)</td>
<td>.084 * (.060)</td>
<td>.051 (.059)</td>
<td>.032 (.072)</td>
<td>.098 * (.019)</td>
</tr>
</tbody>
</table>

* denotes a Hu score that is higher than the corresponding Hc score.
cells for each of the separate ANOVAs. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of covariance was not met in any of the five ANOVAs for the main effect of perceived emotion nor for any of the interactions involving perceived emotion. The Greenhouse-Geisser adjustment to the degrees of freedom was used for all main effects and interactions where the assumption of homogeneity of covariance was not met.

A 5 (perceived emotion) x 2 (H vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of happiness. With alpha set at .05 two main effects were found to be significant: Perceived emotion, $F(2.30, 73.63) = 512.90, p < .001$, partial $\eta^2 = .94$, obs. power = 1.00; Hc vs H, $F(1, 32) = 814.27, p < .001$, partial $\eta^2 = .96$, obs. power = 1.00. However, the main effect of walker gender did not reach significance, $F(1, 32) = .05, p = .83$, partial $\eta^2 = .00$, obs. power = .06. Of the four possible interactions three were significant: Perceived emotion by Hc vs H, $F(1.60, 51.22) = 688.32, p < .001$, partial $\eta^2 = .96$, obs. power = 1.00; perceived emotion by gender, $F(1.90, 60.64) = 3.58, p = .04$, partial $\eta^2 = .10$, obs. power = 0.63; and perceived emotion by Hc vs H by gender, $F(1.78, 56.86) = 4.28, p = .02$, partial $\eta^2 = .12$, obs. power = .69. However, the interaction Hc vs H by gender did not reach significance; $F(1, 32) = .83, p = .37$, partial $\eta^2 = .03$, obs. power = .14. Descriptive statistics are shown in Figure 8.1.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above
chance when the point-light walkers were displaying happiness and thus will not be discussed here. Three of the remaining five relevant post-hoc comparisons reached

a) Female Walkers

![Graph showing mean Hu and Hc scores (proportions) for each perceived emotion when happiness was displayed by female walkers. Error bars depict 95% confidence intervals.]

b) Male Walkers

![Graph showing mean Hu and Hc scores (proportions) for each perceived emotion when happiness was displayed by male walkers. Error bars depict 95% confidence intervals.]

Figure 8.1. Mean Hu and Hc scores (proportions) for each perceived emotion when happiness was displayed by a) female and b) male point-light walkers. Error bars depict 95% confidence intervals.
significance. Happy point-light walkers were perceived as displaying happiness significantly above chance for both female, \( t(32) = 23.49, p < .05 \); and male walkers, \( t(32) = 31.39, p < .05 \). Happy point-light walkers were also perceived as displaying anger significantly above chance in male walkers, \( t(32) = 3.94, p < .05 \), but not in female walkers, \( t(32) = .73, p > .05 \). There was no significant difference in how happy point-light walkers were correctly perceived between female and male walkers, \( t(32) = .10, p > .05 \). The results therefore suggest that when a point-light walker displays happiness then perceivers will also perceive the walker as displaying happiness. The results also indicate that happy point-light walkers can be confused as displaying anger but only in male walkers.

A 5 (perceived emotion) x 2 (H vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of sadness. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, \( F(1.67, 53.31) = 187.64, p < .001 \), partial \( \eta^2 = .85 \), obs. power = 1.00; H vs. Hc, \( F(1, 32) = 339.73, p < .001 \), partial \( \eta^2 = .91 \), obs. power = 1.00; walker gender, \( F(1, 32) = 33.01, p < .001 \), partial \( \eta^2 = .51 \), obs. power = 1.00. Of the four possible interactions three were significant: Perceived emotion by H vs. Hc, \( F(1.35, 43.31) = 344.54, p < .001 \), partial \( \eta^2 = .92 \), obs. power = 1.00; H vs. Hc by gender, \( F(1, 32) = 33.55, p < .001 \), partial \( \eta^2 = .51 \), obs. power = 1.00; and perceived emotion by H vs. Hc by gender, \( F(1.44, 46.00) = 13.86, p < .001 \), partial \( \eta^2 = .30 \), obs. power = .99. However, the interaction perceived emotion by gender did not reach significance; \( F(1.78, 56.95) = .77, p = .45 \), partial \( \eta^2 = .02 \), obs. power = .17. Descriptive statistics are shown in Figure 8.2.
a) Female Walkers

![Graph showing mean Hu and Hc scores for female walkers.]

b) Male Walkers

![Graph showing mean Hu and Hc scores for male walkers.]

*Figure 8.2.* Mean Hu and Hc scores (proportions) for each perceived emotion when sadness was displayed by a) female and b) male point-light walkers. Error bars depict 95% confidence intervals.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not
inform on the investigation of which emotion is perceived significantly above chance when the point-light walkers were displaying sadness and thus will not be discussed here. Four of the five remaining relevant post-hoc comparisons reached significance. Sad point-light walkers were perceived as displaying sadness significantly above chance for both female, \( t(32) = 19.19, p < .05 \); and male walkers, \( t(32) = 15.63, p < .05 \). Sad point-light walkers were also perceived as displaying neutral emotion significantly above chance in both female walkers, \( t(32) = 6.83, p < .05 \), and male walkers, \( t(32) = 4.50, p < .05 \). However, sad point-light walkers were not correctly perceived significantly more in female walkers than male walkers, \( t(32) = 2.83, p > .05 \). The results therefore suggest that when a point-light walker displays sadness then perceivers will also perceive the walker as displaying sadness. The results also indicate that sad point-light walkers can be confused as displaying neutral emotion.

A 5 (perceived emotion) x 2 (Hv vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of anger. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, \( F(2.06, 66.05) = 180.12, p < .001 \), partial \( \eta^2 = .85 \), obs. power = 1.00; Hv vs Hc, \( F(1, 32) = 208.73, p < .001 \), partial \( \eta^2 = .87 \), obs. power = 1.00; walker gender, \( F(1, 32) = 38.58, p < .001 \), partial \( \eta^2 = .55 \), obs. power = 1.00. All interactions were also significant: Perceived emotion by Hv vs Hc, \( F(1.40, 44.94) = 356.70, p < .001 \), partial \( \eta^2 = .92 \), obs. power = 1.00; perceived emotion by gender, \( F(1.66, 53.20) = 44.13, p < .001 \), partial \( \eta^2 = .58 \), obs. power = 1.00; Hv vs Hc by gender, \( F(1, 32) = 40.06, p < .001 \), partial \( \eta^2 = .56 \), obs. power = 1.00; and perceived emotion by Hv vs Hc by gender,
$F(1.35, 43.12) = 36.78, p < .001$, partial $\eta^2 = .54$, obs. power = 1.00. Descriptive statistics are shown in Figure 8.3.

a) Female Walkers

![Graph showing mean Hu and Hc scores for female walkers.]

b) Male Walkers

![Graph showing mean Hu and Hc scores for male walkers.]

*Figure 8.3.* Mean Hu and Hc scores (proportions) for each perceived emotion when anger was displayed by a) female and b) male point-light walkers. Error bars depict 95% confidence intervals.
All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above chance when the point-light walkers were displaying anger and thus will not be discussed here. The remaining three relevant post-hoc comparisons all reached significance. Angry point-light walkers were perceived as displaying anger significantly above chance for both female, \( t(32) = 16.94, p < .05 \); and male walkers, \( t(32) = 16.45, p < .05 \). Angry point-light walkers were correctly perceived significantly more in female walkers than male walkers, \( t(32) = 6.97, p < .05 \). The results therefore suggest that when a point-light walker displays anger then perceivers will also perceive the walker as displaying anger. However, anger was identified better when the walker was female.

A 5 (perceived emotion) x 2 (H vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of fear. With alpha set at .05 two main effects were found to be significant: Perceived emotion, \( F(1.81, 58.04) = 64.43, p < .001 \), partial \( \eta^2 = .67 \), obs. power = 1.00; HvsHc, \( F(1, 32) = 164.99, p < .001 \), partial \( \eta^2 = .84 \), obs. power = 1.00. However, the main effect of walker gender did not reach significance, \( F(1, 32) = 1.98, p = .17 \), partial \( \eta^2 = .06 \), obs. power = .28. Of the four possible interactions two were significant: Perceived emotion by HvsHc, \( F(1.51, 48.18) = 107.21, p < .001 \), partial \( \eta^2 = .77 \), obs. power = 1.00; perceived emotion by gender, \( F(2.08, 66.61) = 7.37, p < .001 \), partial \( \eta^2 = .19 \), obs. power = .94. However, the two interactions HvsHc by gender, \( F(1, 32) = .02, p = .90 \), partial \( \eta^2 = .00 \), obs. power = .05, and perceived emotion by HvsHc by gender,
\( F(1.90, 60.94) = 2.04, p = .14, \) partial \( \eta^2 = .06, \) obs. power = .40, did not reach significance. Descriptive statistics are shown in Figure 8.4.

a) Female Walkers

![Graph showing mean Hu and Hc scores for perceived emotions](image)

Hue vs Hc
- Hu
- Hc

b) Male Walkers

![Graph showing mean Hu and Hc scores for perceived emotions](image)

Hue vs Hc
- Hu
- Hc

*Figure 8.4.* Mean Hu and Hc scores (proportions) for each perceived emotion when fear was displayed by a) female and b) male point-light walkers. Error bars depict 95% confidence intervals.
All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above chance when the point-light walkers were displaying fear and thus will not be discussed here. Four of the five remaining relevant post-hoc comparisons reached significance. Fearful point-light walkers were perceived as displaying fear significantly above chance for both female, $t(32) = 16.82, p < .05$; and male walkers, $t(32) = 8.65, p < .05$. Fearful point-light walkers were also perceived as displaying sadness significantly above chance in both female walkers, $t(32) = 4.47, p < .05$, and male walkers, $t(32) = 4.54, p < .05$. There was no significant difference in how fearful point-light walkers were correctly perceived between female and male walkers, $t(32) = 1.45, p > .05$. The results therefore suggest that when a full-light walker displays fear then perceivers will also perceive the walker as displaying fear. The results also indicate that fearful point-light walkers can be confused as displaying sadness.

A 5 (perceived emotion) x 2 (H vs. Hc) x 2 (walker gender) repeated ANOVA was conducted for the displayed emotion of neutral. With alpha set at .05 two main effects were found to be significant: Perceived emotion, $F(1.31, 42.06) = 132.63, p < .001$, partial $\eta^2 = .81$, obs. power = 1.00; H vs Hc, $F(1, 32) = 104.79, p < .001$, partial $\eta^2 = .77$, obs. power = 1.00. However, the main effect of walker gender, $F(1, 32) = 2.02, p = .17$, partial $\eta^2 = .06$, obs. power = .28, did not reach significance. Of the four possible interactions three were found to be significant: Perceived emotion by H vs Hc, $F(1.16, 37.10) = 147.28, p < .001$, partial $\eta^2 = .82$, obs. power = 1.00; perceived emotion by gender, $F(1.39, 44.31) = 5.51, p = .02$,
partial $\eta^2 = .15$, obs. power = .72; and perceived emotion by H vs Hc by gender, $F(1.29, 41.21) = 9.97$, $p < .001$, partial $\eta^2 = .24$, obs. power = .92. However, the interaction H vs Hc by gender did not reach significance, $F(1, 32) = 3.03$, $p = .09$, partial $\eta^2 = .09$, obs. power = .39. Descriptive statistics are shown in Figure 8.5.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above chance when the point-light walkers were displaying neutral and thus will not be discussed here. Two of the four remaining relevant post-hoc comparisons reached significance. Neutral point-light walkers were perceived as displaying neutral significantly above chance for both female, $t(32) = 10.62$, $p < .05$; and male walkers, $t(32) = 10.15$, $p < .05$. There was no significant difference in how neutral point-light walkers were correctly perceived between female and male walkers, $t(32) = 2.46$, $p > .05$. Additionally male neutral point-light walkers were not perceived as displaying anger significantly above chance, $t(32) = 1.25$, $p > .05$. The results therefore suggest that when a full-light walker displays neutral emotion then perceivers will also perceive the walker as displaying neutral emotion.

In each of the repeated measures ANOVAs conducted it was found that the emotion displayed was the emotion perceived significantly above chance. However, this analysis does not show which emotions are perceived better than others. Thus another 5 (Identified emotion) x 2 (H vs Hc) x 2 (walker gender) repeated measures ANOVA was conducted for the correctly perceived emotions (see the bolded
a) Female Walkers

![Graph showing mean Hu and Hc scores for each perceived emotion when neutral was displayed by female point-light walkers.]

b) Male Walkers

![Graph showing mean Hu and Hc scores for each perceived emotion when neutral was displayed by male point-light walkers.]

Figure 8.5. Mean Hu and Hc scores (proportions) for each perceived emotion when neutral was displayed by a) female and b) male point-light walkers. Error bars depict 95% confidence intervals.

The assumption of homogeneity of covariance was not met for any of the main effects or interactions which incorporated the variable of identified emotions. Therefore the Greenhouse-Geisser adjustment to the degrees of
freedom was used for all main effects and interactions where the assumption of homogeneity of covariance was not met. With alpha set at .05 all three main effects were found to be significant: Perceived emotion, $F(2.53, 80.99) = 67.70$, $p < .001$, partial $\eta^2 = .70$, obs. power = 1.00; $Hu vs Hc$, $F(1, 32) = 549.19$, $p < .001$, partial $\eta^2 = .95$, obs. power = 1.00; walker gender, $F(1, 32) = 39.68$, $p < .001$, partial $\eta^2 = .55$, obs. power = 1.00. All interactions were also significant: Identified emotion by $Hu vs Hc$, $F(2.08, 66.56) = 50.85$, $p < .001$, partial $\eta^2 = .61$, obs. power = 1.00; identified emotion by gender, $F(2.58, 82.41) = 8.37$, $p < .001$, partial $\eta^2 = .21$, obs. power = .98; $Hu vs Hc$ by gender, $F(1, 32) = 34.94$, $p < .001$, partial $\eta^2 = .52$, obs. power = 1.00; and identified emotion by $Hu vs Hc$ by walker gender, $F(2.45, 78.47) = 6.11$, $p < .001$, partial $\eta^2 = .16$, obs. power = .92. Descriptive statistics are shown in Figure 8.6.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of how well each emotion is relatively identified and thus will not be discussed here. The $Hu$ scores for each emotion were compared with the $Hu$ scores for each other emotion. The post-hoc comparisons were done separately for each walker gender. Thus the remaining 20 relevant post-hoc comparisons are described here. Happiness was identified significantly more than sadness in male point-light walkers, $t(32) = 3.94$, $p < .05$; but not female full-light walkers, $t(32) = .66$, $p > .05$. Happiness was identified significantly higher than anger in male point-light walkers, $t(32) = 11.36$, $p < .05$; but not in female point-light walkers, $t(32) = 1.05$, $p > .05$. Happiness was identified significantly better than neutral in both male, $t(32) = 32.20$, $p < .05$; and female walkers, $t(32) = 18.10$, $p < .05$.
a) Female Walkers

b) Male Walkers

Figure 8.6. Mean Hu and Hc scores (proportions) for each correctly perceived emotion when displayed by a) female and b) male point-light walkers. Error bars depict 95% confidence intervals.

p < .05. Sadness was identified significantly better then anger in male, t(32) = 4.15, p < .05; but not female walkers, t(32) = .19, p > .05. Sadness was identified significantly better than neutral for both male, t(32) = 12.33, p < .05; and female
walkers, $t(32) = 11.12$, $p < .05$. Anger was identified significantly better than neutral in both male, $t(32) = 9.42$, $p < .05$; and female walkers, $t(32) = 13.15$, $p < .05$. Fear was also identified significantly better than neutral in both male, $t(32) = 5.77$, $p < .05$; and female walkers, $t(32) = 10.15$, $p < .05$. However, there was no significant difference between the identification rates for sadness and fear for both male, $t(32) = .08$, $p > .05$; and female walkers, $t(32) = .51$, $p > .05$. There was no significant difference between the identification rates for fear and happiness for both male, $t(32) = 1.91$, $p > .05$; and female point-light walkers, $t(32) = 1.12$, $p > .05$. There was also no significant difference in the identification rates between fear and anger in both male, $t(32) = 2.38$, $p > .05$; and female walkers, $t(32) = .27$, $p > .05$. The perceiver’s emotion identification order was different for each walker gender. When the point-light walker was male happiness was identified most accurately followed by sadness and then by anger, however, each of these emotions was identified equally well with fear. When the point-light walker was female each of the four emotions (i.e. happy, sad, anger and fear) was identified equally well. Neutral was identified the poorest for both walker genders. Additionally, previous analyses indicated that the emotions sadness and anger were identified better when the point-light walker was female.

8.3.2. Testing the Alarm Hypothesis in Point-light Walkers

8.3.2.1. Perceiver Ratings of the Intensity of the Emotion Displayed by Point-light Walkers

A 4 (displayed emotion) x 3(intensity) x 2 (walker gender) Repeated Measures ANOVA was conducted to investigate whether perceiver ratings of the emotional intensity of point-light walkers were influenced by the specific emotion displayed by
a walker, by the level of displayed emotional intensity and by the gender of the walker. Only perceiver ratings from correct identifications (i.e. displayed emotion = perceived emotion) were used in this analysis. The average correct rating for each perceiver for each cell of the design was used as the data scores. However, four participants failed to make a correct identification in one or more of the conditions thus some cells had missing scores. All scores for those four participants were therefore deleted from the repeated measures analysis thus each cell had 30 observations. Neutral was dropped from this analysis because neutral only has a single level of displayed intensity and was consequently only able to be rated by perceivers as expressing an intensity level of ‘5’ (see section 7.2.2.). Outliers were identified in multiple cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The rest of the assumptions of the ANOVA were deemed satisfactory.

With alpha set at .05 all three main effects were found to be significant: Displayed emotion, $F(3, 696) = 33.52$, $p < .001$, partial $\eta^2 = .54$, obs. power = 1.00; intensity, $F(2, 696) = 136.27$, $p < .001$, partial $\eta^2 = .83$, obs. power = 1.00; walker gender, $F(1, 696) = 25.86$, $p < .001$, partial $\eta^2 = .83$, obs. power = 1.00. There were also three significant interactions: displayed emotion by intensity, $F(6, 696) = 2.53$, $p = .02$, partial $\eta^2 = .08$, obs. power = 0.83; displayed emotion by walker gender, $F(3, 696) = 27.60$, $p < .001$, partial $\eta^2 = .49$, obs. power = 1.00; and intensity by walker gender, $F(2, 696) = 4.08$, $p = .02$, partial $\eta^2 = .12$, obs. power = 0.70. The relatively low effect sizes for the interactions emotion by intensity and intensity by gender still produced high statistical power. This indicates that the mean differences
were not that large but the large sample size may have inflated both the significance levels and the observed power. Descriptive statistics are shown in Figure 8.7.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on how the data may relate to the hypothesised pattern of results (i.e. alarm hypothesis, Walk & Homan, 1984). Thus the remaining 19 relevant post-hoc comparisons are reported here. It should be noted that the intention of these analyses were to see how each identified emotion was rated by perceivers relative to other identified emotions of the same level of displayed intensity. Therefore, none of the reported post-hoc comparisons contrasted across different displayed intensity levels. All assumptions for the paired sample t-tests were deemed satisfactory. Only seven of these post-hoc comparisons reached significance. Anger was rated significantly higher than sadness in female walkers for both high, $t(29) = 11.26, p < .05$, and low intensities, $t(29) = 5.97, p < .05$. Anger was also rated significantly higher than fear at high intensity in female walkers, $t(29) = 4.07, p < .05$. Fear was rated significantly higher than sadness at moderate intensity in female walkers, $t(29) = 4.99, p < .05$. Angry female walkers were rated significantly higher than angry male walkers for low, $t(29) = 3.89, p < .05$, moderate, $t(29) = 8.17, p < .05$, and high intensities, $t(29) = 7.84, p < .05$.

It should be noted that since the perceiver ratings used in this analysis were only from correct categorisations, a lower rating indicates a greater attunement to the perception of that emotion (i.e. the emotion does not need to be perceived as intense.
a) the Female Walkers

![Graph showing mean ratings of perceived emotional intensity for female walkers across different intensities of displayed emotion.]

b) Male Walkers

![Graph showing mean ratings of perceived emotional intensity for male walkers across different intensities of displayed emotion.]

Figure 8.7. Mean correct perceiver ratings of emotional intensity for the specific emotions at each level of displayed intensity for a) female and b) male point-light walkers. Error bars depict 95% confidence intervals.
in order to be accurately perceived). The results therefore suggest that perceivers are most attuned to the perception of sadness compared to other emotions but only in female walkers. The results also indicate that perceivers are more attuned to the perception of anger in male walkers compared to female walkers.

8.3.2.2. Reaction Times for the Perception of Emotions in Point-light

Walkers

A 5 (displayed emotion) x 2 (gender) x 2 (accuracy) repeated measures ANOVA was conducted looking at the perceiver reaction times. Due to the nature of the accuracy variable a perceiver failed to categorise the emotion displayed by a walker in a specific cell correctly, thus the cell had a missing score. To eliminate the missing score from the repeated measures design a single perceiver had their scores eliminated from each cell of the analysis thus there were 33 scores in each cell. The mean reaction times for each perceiver for each cell of the design were used as the data scores for this analysis in order to reduce the high degrees of freedom. An outlier was identified in a single cell. The outlier was reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of covariance was not met for any of the main effects or interactions thus the Greenhouse-Geisser adjustment to the degrees of freedom was used for all main effects and interactions. The rest of the assumptions of the ANOVA were deemed satisfactory.

With alpha set at .05 two main effects were found to be significant: Displayed emotion, \( F(1.73, 640) = 36.34, \ p < .001, \ \text{partial } \eta^2 = .53, \ \text{obs. power} = 1.00; \) and accuracy, \( F(1, 640) = 45.86, \ p < .001, \ \text{partial } \eta^2 = .59, \ \text{obs. power} = 1.00. \)
All two way interactions were also found to be significant: Displayed emotion by gender, $F(2.98, 640) = 13.84$, $p < .001$, partial $\eta^2 = .30$, obs. power = 1.00; displayed emotion by accuracy, $F(3.01, 640) = 6.87$, $p < .001$, partial $\eta^2 = .18$, obs. power = .97; and gender by accuracy, $F(1, 640) = 17.44$, $p < .001$, partial $\eta^2 = .35$, obs. power = .98. The three way interaction was not significant, $F(2.67, 640) = 1.11$, $p = .35$, partial $\eta^2 = .03$, obs. power = .27. Descriptive statistics are shown in Figure 8.8.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on whether the alarm hypothesis (Walk & Homan, 1984) could explain the pattern of results and therefore make sense of the inconclusive findings in the results from the previous analyses. Thus the remaining 12 relevant post-hoc comparisons are reported here. All assumptions for the paired sample $t$-tests were deemed satisfactory. Only six of these post-hoc comparisons reached significance. Anger was correctly identified significantly faster than fear in both male, $t(32) = 6.16$, $p < .05$; and female walkers, $t(32) = 5.95$, $p < .05$. Anger was categorised significantly faster for correct categorisations than incorrect categorisations for both male, $t(32) = 7.17$, $p < .05$; and female walkers, $t(32) = 8.23$, $p < .05$. Fear was also categorised significantly faster for correct categorisations than for incorrect categorisations for female, $t(32) = 3.93$, $p < .05$; but not for male walkers, $t(32) = .61$, $p > .05$. Correctly identified fear was identified significantly faster in female walkers compared to male walkers, $t(32) = 4.69$, $p < .05$. However, there was no significant difference in the reaction times for perceiving anger correctly between male and female walkers, $t(32) = 2.90$, $p > .05$. There was no significant difference between correct and incorrect categorisations of neutral for both male, $t(32) = .02$, $p > .05$; and female
walkers, $t(32) = .88, p > .05$. There was also no significant difference between the reaction times required to correctly identify happiness and anger in female walkers, $t(32) = 1.20, p > .05$, and male walkers, $t(32) = .98, p > .05$.

a) Correct Categorisations

![Graph showing mean reaction times for correct categorisations]

b) Incorrect Categorisations

![Graph showing mean reaction times for incorrect categorisations]

Figure 8.8. Mean reaction times (ms) for the a) correct and b) incorrect categorisations of the specific emotions for both male and female point-light walkers. Error bars depict 95% confidence intervals.
The descriptive statistics shown in Figure 8.8 suggest a pattern in the reaction time data that is consistent for both genders and the reaction time results of the previous full-light experiment: specifically, happy and angry walkers were identified faster than sad or fearful walkers. In the previous full-light experiment, we found that the differing duration of the full-light walker video clips was significantly correlated with the perceiver identification times. As such, we repeated the same four additional analyses that were conducted in the previous full-light experiment (see section 7.3.2.2.). Firstly, to verify that happy and angry walkers were indeed identified faster than sad and fearful walkers, we conducted a series of paired-sample t-tests comparing the identification times for each displayed emotion against each other displayed emotion. These analyses were conducted separately for both walker genders. Secondly, for comparative data, we analysed how the duration of the point-light walker video clips differed for each displayed emotion. Thirdly, we conducted a correlation to investigate the relationship between the duration of the full-light walker clips and the perceiver identification times. Lastly, we conducted a correlation on whether there was a relationship between the frequency of identifications for each emotion and the duration of the point-light walker video clips depicting those same emotions.

Our earlier analysis of the perceiver identification reaction time data was aimed specifically to test the alarm hypothesis (Walk & Homan, 1984). However, to discount this possible methodological confound of our experiment, we were required to conduct the first of our additional analyses. In our earlier analysis, we already found that anger was identified faster than fear in both male, \( t(32) = 6.16, p < .05; \)
and female point-light walkers, \( t(32) = 5.95, p < .05 \). We also found no significant difference between the identification times for happiness and anger in female walkers, \( t(32) = 1.20, p > .05 \), and male walkers, \( t(32) = .98, p > .05 \). Therefore those comparisons did not need to be included in the additional analyses. All other displayed emotion comparisons (not including neutral) were made separately for both walker genders thus eight paired sample t-tests were conducted using the Tukey correction of alpha for multiple comparisons. Happiness was identified faster than sadness for both male, \( t(32) = 4.12, p < .05 \); and female walkers, \( t(32) = 7.77, p > .05 \). Happiness was also identified faster than fear for both male, \( t(32) = 5.86, p > .05 \); and female walkers, \( t(32) = 7.02, p > .05 \). Anger was also identified faster than sadness for both male, \( t(32) = 4.84, p > .05 \); and female walkers, \( t(32) = 6.05, p > .05 \). Fear was not identified faster than sadness in female walkers, \( t(32) = 3.11, p > .05 \); nor male walkers, \( t(32) = 2.64, p > .05 \). Happy and angry walkers were identified faster than sad and fearful walkers.

Our second additional analysis investigated whether the point-light walker video clips differed in duration between the emotions. The duration of each video clip constituted the dependant variable. Outliers were identified in several cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of variance was not met thus the nonparametric Kruskal-Wallis test was conducted. The Kruskal-Wallis was significant, \( \chi^2(4, N = 409) = 116.90, p < .001 \). All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to understand how the point-light walker video clip duration differed for each displayed emotion. Mann-Whitney tests were conducted for these 10 post-hoc
comparison with a Bonferroni correction of alpha of .005. Only six of these post-hoc comparisons reached significance. Sad walker video clips were of significantly longer duration than happy, \(z(N = 194) = 8.74, p < .001\); angry, \(z(N = 201) = 8.02, p < .001\); and neutral video clips, \(z(N = 132) = 4.96, p < .001\). Fearful walker video clips were also of significantly longer duration than happy, \(z(N = 177) = 6.58, p < .001\); angry, \(z(N = 184) = 6.13, p < .001\); and neutral video clips, \(z(N = 115) = 3.71, p < .001\). However, there was no significant difference between the duration of happy walker videos and that of angry, \(z(N = 193) = .47, p = .639\); nor neutral walker video clips, \(z(N = 124) = 2.17, p = .030\). Nor was there a difference between the duration of angry and neutral walker video clips, \(z(N = 131) = 1.71, p = .088\). There was also no significant difference between the duration of sad walker and fearful walker video clips, \(z(N = 185) = .29, p = .774\). Descriptive statistics are shown in Figure 8.9.

Because our video duration analysis results largely mirrored the emotion identification time data, we conducted a correlation between the duration of each video clip and the perceiver identification times for that clip. All assumptions were satisfied. With alpha set at .05, a significant positive correlation was found, \(r(409) = .782, p < .001\), indicating that a longer point-light walker video clip was associated with increased perceiver identification times for the displayed emotions.

Our last additional analysis investigated whether the video duration influenced how often they identified a particular emotion by correlating the duration of each point-light walker video clip and the frequency of identifications for that clip across all perceivers. All assumptions of the correlation were satisfied. With alpha
was set at .05, no significant correlation was found, $r(409) = .043$, $p = .387$, indicating that the duration of the point-light walker video clip had no effect on how often perceivers identified the emotion displayed by the walker.

![Mean Video Duration (s) for emotions](image)

*Figure 8.9.* Mean duration times (s) for the point-light walker video clips displaying each emotion.

### 8.3.3. Most Commonly Reported Strategies for Identifying Emotions in Point-light Walkers

This section will report the most pertinent types of movements that perceivers reported to use to identify the specific emotions. For each emotion three or four movements were reported by perceivers to identify the specific emotions. Only the three or four most frequently reported strategies will be described. Furthermore, these results will be discussed later in comparison to the identification strategies reported by perceivers for full-light walkers (Table 8.4).
Table 8.4

*A Comparison between the Most Frequently Reported Strategies by Perceivers for Identifying the Emotion Displayed by Full-light and Point-light Walkers.*

<table>
<thead>
<tr>
<th>Emotion</th>
<th>Stimulus Display</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Full-light Walker</td>
</tr>
<tr>
<td>Happy</td>
<td>1) Bouncy Gait (27/125)</td>
</tr>
<tr>
<td></td>
<td>2) (\uparrow) Arm Movement (26/125)(^a)</td>
</tr>
<tr>
<td></td>
<td>3) Head up (20/125)</td>
</tr>
<tr>
<td>Sad</td>
<td>1) Head Down (37/123)</td>
</tr>
<tr>
<td></td>
<td>2) Slower Walk (34/123)</td>
</tr>
<tr>
<td></td>
<td>3) Shoulders Slumped (8/123)</td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Anger</td>
<td>1) Faster Walk (31/139)</td>
</tr>
<tr>
<td></td>
<td>2) Hands Clenched (25/139)</td>
</tr>
<tr>
<td></td>
<td>3) Stomping (24/139)</td>
</tr>
<tr>
<td>Fear</td>
<td>1) Looking Around (36/127)</td>
</tr>
<tr>
<td></td>
<td>2) Faster Walk (23/127)</td>
</tr>
<tr>
<td></td>
<td>3) Slower Walk (16/127)</td>
</tr>
</tbody>
</table>

*Note.* The averaged frequencies of comments in relation to the averaged total number of comments made for that emotion are given in corresponding parentheses. \(^a\)\(\uparrow\) denotes more or larger movement. \(^b\)\(\downarrow\) denotes less or smaller movement.
The perceiver identification strategies were coded by four separate researchers and a frequency tally was taken for each identification strategy. The mean frequencies (rounded to nearest integer) across the four coders will be reported here. An intraclass correlation coefficient was calculated for each emotion as a measure of the degree of agreement between the three coders: Happy = .97; Sad = .99; Anger = .95; and Fear = .98.

8.3.3.1. Identification Strategies for Happy Walkers

A total of 107 comments (averaged across the four coders) were made by perceivers, which was divided into 24 separate strategies for identifying point-light walkers displaying happiness. The most frequently reported strategy was ‘bouncy gait’ (22/107) which referred to the walker having a spring in their step as if they were dancing along. The second most frequently reported strategy was ‘increased arm movement’ (17/107) which referred to the walkers displaying long arm swings that rotated around the body. The next most frequently reported strategy was ‘faster walk’ (17/107) which referred to the walker displaying a faster pace.

8.3.3.2. Identification Strategies for Sad Walkers

An averaged total of 108 comments were made which was divided into 17 separate strategies for identifying walkers displaying sadness. The most frequently reported strategy was ‘slower walk’ (33/108) which referred to the walker displaying a slower pace. The next most frequent reported strategies were ‘head down’ (19/108, lowering their head towards their chest, ‘less arm movement’ (10/108, shorter arm swing) and non-linear path (10/108, snaking a path forward towards the perceiver).
8.3.3.3. Identification Strategies for Angry Walkers

An averaged total of 95 comments from 23 different strategies were made by perceivers for identifying anger in point-light walkers. The most frequently reported strategies were ‘faster walk’ (25/95), ‘stomping’ (22/95), and ‘long arm swing’ (8/95).

8.3.3.4. Identification Strategies for Fearful Walkers

An averaged total of 107 comments from 21 different strategies were made by perceivers for identifying fear in point-light walkers. The most frequently reported strategies were ‘turning head’ (26/107, as if looking around), ‘slower walk’ (17/107), and ‘faster walk’ (9/107).

8.3.4. Kinematic Analysis of Key Identified Gait Features for each Emotion

So far, we have assumed that the perceiver reported identification strategies were valid indicators of which gait movements communicate which specific emotions. However, this assumption rests on two premises: 1) Perceivers were aware of the gait movements that they used to discriminate between the different displayed emotions. 2) The reported identification strategies were successful in discriminating between the kinematics of the emotion specific walking styles. This assumption can now be tested through kinematic analysis. As the point-light walkers were constructed from motion tracking data, the original measurements in Cartesian coordinates over time are directly suitable for kinematic analysis. Only walkers that were correctly identified more than 25% of the time but not confused as displaying another emotion more than 25% of the time were judged to be suitable for kinematic analysis. Typically, actor walkers who were more proficient at displaying certain
emotions were also reliably identified as displaying that emotion at lower displayed intensities. The walking stimuli of these ‘good actors’, irrespective of intended displayed intensity, were thus also judged as suitable for inclusion in these kinematic analyses. By restricting the kinematic analyses to reliably and validly identified walkers, the influence of ‘bad actors’ can be minimised thus rendering the kinematic analyses more meaningful. Consequently, 42 happy, 44 sad, 39 angry, 18 fearful and 18 neutral walkers were included in these kinematic analyses.

A series of kinematic analyses were performed on each of the reliably identified point-light walker’s movements to isolate the specific gait features that perceivers reported using (see Table 8.4). Statistical analyses were then conducted to test whether the gait features that perceivers reported for perceptually discriminating each emotion were evident in the kinematics of the walkers displaying those same emotions. Each of the kinematic analyses and the consequent statistical analyses will now be described and reported in turn.

8.3.4.1. Walking Pace

The pace of the walker was identified by perceivers as contributing to the perception of several emotions (see Table 8.4). Perceivers reported that happy and angry walkers walked faster, sad walkers walked slower, and fearful walkers walked both fast and slow. Kinematic analyses were therefore conducted on the pace of the point-light walkers to verify the influence of walking pace on the identification of each specific emotion studied. Remember that the forward translation of each walker was removed from the motion data (see section 8.2.2.) therefore these walking pace analyses utilised alternative kinematic measures to forward translation in order to
objectively measure walking pace. Furthermore, the perceivers who reported using walking pace to distinguish between the displays of the different emotions in point-light walkers were denied access to the translatory information in the stimuli thus they are clearly accessing subcomponent cues of walking pace. Walking pace is measured by the equation: cadence x stride length (see section 4.2.1.) therefore measuring both of these kinematic features, which is possible in the non-translating point-light walkers, gives an accurate measure of each walker’s walking pace. The first of the analyses is the number of gait cycles conducted per second (i.e. cadence). A faster walk should exhibit more gait cycles per second. As such, it is hypothesised from the perceiver identification strategies that happy and angry walkers will exhibit more gait cycles per second, sad walkers will exhibit less gait cycles per second than walkers displaying the other emotions (i.e. fear and neutral). Because the perceivers reported identifying fear by both a faster and slower walking pace, it is likely that the fast (i.e. fleeing) and slow (i.e. cautious) walking paces will statistically cancel each other out therefore producing a walking pace on par with neutral.

As described in greater detail later in section 9.2., the point-light walker motion data was used to create synthetic point-light walker stimuli to be used in the succeeding experiments. During the synthetic walker creation process, a principle components analysis was conducted and a sinusoidal fitted to the first PC of each point-light walker which corresponded to the walker’s fundamental frequency. Walking is a cyclical movement and the fundamental frequency represents how frequent the gait cycle is performed thus we can effectively measure the number of gait cycles per second for each point-light walker.
As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted on the number of gait cycles per second exhibited by the point-light walkers. The dependent variable for the statistical analysis comprised the fundamental frequency for each walker. Several outliers were identified for the emotions happy, anger and fear. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The Kruskal-Wallis test was significant, $\chi^2(4, N = 159) = 101.96, p < .001$. All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to see whether the gait cycle frequency would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. Six of these post-hoc comparisons reached significance. Sad walkers had fewer gait cycles per second than happy, $z(N = 85) = 7.57, p < .001$; angry, $z(N = 81) = 7.73, p < .001$; fearful, $z(N = 61) = 3.97, p < .001$; and neutral walkers, $z(N = 61) = 5.87, p < .001$. Angry walkers had more gait cycles per second than happy, $z(N = 80) = 5.61, p < .001$; and neutral walkers, $z(N = 56) = 5.61, p < .001$. However, there was no significant difference between fearful walkers and happy, $z(N = 60) = .53, p = .594$; angry, $z(N = 56) = 1.65, p = .099$; and neutral walkers, $z(N = 36) = .95, p = .343$. Nor was there a significant difference between happy walkers and neutral walkers, $z(N = 60) = 2.05, p = .040$. Descriptive statistics are shown in Figure 8.10.

Walking pace, however, is not only determined by the number of gait cycles per second, as described above, it is measured by the equation: step length x cadence. A longer stride (i.e. 2 steps thus 1 gait cycle) will produce a faster walk if the same
cadence (i.e. step frequency) is maintained. As such, a second kinematic analysis was conducted to investigate the other term of the walking pace equation: stride length. It can therefore be hypothesised from the perceiver reported identification strategies that happy and angry walkers will exhibit a longer stride length and sad walkers will exhibit a shorter stride length than walkers displaying the other emotions (i.e. fear and neutral).

![Figure 8.10](image.png)

*Figure 8.10.** Mean gait cycles per second for walkers displaying each emotion. Error bars depict 95% confidence intervals.

Walking pace, however, is not only determined by the number of gait cycles per second, as described above, it is measured by the equation: step length x cadence. A longer stride (i.e. 2 steps thus 1 gait cycle) will produce a faster walk if the same cadence (i.e. step frequency) is maintained. As such, a second kinematic analysis was conducted to investigate the other term of the walking pace equation: stride length. It can therefore be hypothesised from the perceiver reported identification strategies that happy and angry walkers will exhibit a longer stride length and sad
walkers will exhibit a shorter stride length than walkers displaying the other emotions (i.e. fear and neutral).

As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted on the stride length exhibited by the point-light walkers. The dependent variable for the statistical analysis comprised the stride length for each walker which was measured kinematically by determining the distance between the Cartesian coordinate of the return points of the right heel marker (i.e. reference leg) on the axis of the walking direction (i.e. forward and backwards). Remember that the forward translation of each walker was removed from the motion data (see section 8.2.2.) therefore the Cartesian coordinates representing the return points of the heel marker of each walker was relatively constant. Several outliers were identified for the emotions sad and anger. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The Kruskal-Wallis test was significant, $\chi^2(4, N = 159) = 86.07, p < .001$. All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to see whether the stride length would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. Seven of these post-hoc comparisons reached significance. Sad walkers had shorter strides than happy, $z(N = 85) = 5.98, p < .001$; angry, $z(N = 81) = 7.36, p < .001$; and neutral walkers, $z(N = 61) = 4.65, p < .001$. Fearful walkers also had shorter strides than happy, $z(N = 85) = 4.71, p < .001$; angry, $z(N = 81) = 5.58, p < .001$; and neutral walkers, $z(N = 61) = 3.92, p < .001$. However, there was no significant difference between the mean stride lengths of sad
and fearful walkers, \( z(N = 61) = 1.85, p = .064 \). Angry walkers had longer strides than neutral walkers, \( z(N = 56) = , p = .001 \); but not happy walkers, \( z(N = 80) = 2.66, p = .008 \). Additionally, there was no significant difference in the stride length between happy and neutral walkers, \( z(N = 60) = 1.42, p = .156 \). Descriptive statistics are shown in Figure 8.11.

![Figure 8.11](image)

*Figure 8.11.* Mean stride length (represented by Cartesian coordinate distances) for walkers displaying each emotion. Error bars depict 95% confidence intervals.

The combination of these two conducted kinematic analyses gives a clear indication of how walking pace impacts on the expression, and thus perception of different emotions. Happy walkers walked with a long steady stride. Angry walkers walked with a long fast stride, consequently creating a faster walk (i.e. walking pace = cadence \( \times \) stride length). Fearful walkers walked with fast short strides reminiscent of a scurrying gait. Sad walkers walked with slow short strides consequently creating the slowest walking pace.
8.3.4.2. Arm Movement

The degree of arm movement was identified by perceivers as contributing to the perception of several emotions (see Table 8.4). Perceivers reported that happy walkers had increased arm swing, sad walkers had decreased arm swing and angry walkers had long arm swing. Kinematic analyses were therefore conducted on the arm swing of the point-light walkers to verify these identified arm gait movements characteristic of each specific emotion. Arm swing gait features were kinematically measured in the point-light walkers through two separate analyses. The first of which is the measurement of the range of motion of the right wrist marker (i.e. reference arm). The wrist marker is the most peripheral marker of the pendulum-like swing of the walkers arm and thus is most suitable for the measurement of the degree of arm movement. It is hypothesised from the perceiver identification strategies that happy and angry walkers will exhibit more wrist marker range of motion and sad walkers will exhibit less range of motion than walkers displaying the other emotions (i.e. fear and neutral).

As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted on the wrist marker range of motion. The dependent variable for the statistical analysis was measured kinematically by determining the Euclidean distance between the Cartesian coordinate of the return points of the right wrist marker on the axis of the walking direction (i.e. forward and backwards). Several outliers were identified for the emotions happy and sad. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The Kruskal-Wallis test was significant, $\chi^2(4, N = 159) = 79.55, p < .001$. All displayed
emotion combinations were compared thus 10 post-hoc comparisons were made to see whether the wrist’s range of motion would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. Seven of these post-hoc comparisons reached significance. Happy walkers had greater wrist marker range of motion than sad, \( z(N = 85) = 7.40, p < .001 \); fearful, \( z(N = 60) = 4.42, p < .001 \); and neutral walkers, \( z(N = 60) = 4.26, p < .001 \). Angry walkers also had greater wrist marker range of motion than sad, \( z(N = 81) = 6.31, p < .001 \); fearful, \( z(N = 56) = 3.61, p < .001 \); and neutral walkers, \( z(N = 56) = 3.40, p = .001 \). However, there was no significant difference between the wrist markers range of motion of happy and angry walkers, \( z(N = 80) = .25, p = .802 \). Neutral walkers had greater wrist marker range of motion than sad walkers, \( z(N = 61) = 3.69, p < .001 \). Additionally, there was no significant difference in the wrist markers range of motion between fearful and sad walkers, \( z(N = 61) = 2.61, p = .009 \); nor with neutral walkers, \( z(N = 36) = .44, p = .658 \). Descriptive statistics are shown in Figure 8.12.

To complete the picture, a second kinematic analysis was conducted to distinguish between the reported increased arm movement of happy walkers and the long arm movements of angry walkers. The increased arm movement of happy walkers may be seen by a greater degree of elbow flexion which consequently reduces the Euclidean distance of the wrist markers range of motion. An angry walker’s arm swing may look long, as opposed to increased, because their arms do not bend (i.e. reduced elbow flexion) throughout a large arm swing. It is therefore hypothesised that happy walkers will exhibit more right elbow flexion (i.e. reference arm) in their walk than angry walkers.
Figure 8.12. Mean range of motion of the right wrist marker (represented by Cartesian coordinate Euclidean distances) for walkers displaying each emotion. Error bars depict 95% confidence intervals.

As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted on the degree of variation in elbow flexion exhibited by the point-light walkers. The dependent variable for the statistical analysis comprised the standard deviation of the elbow angle (relative to the wrist and shoulder points) for each walker. The standard deviation of the elbow angle is a measure sensitive to the variation in arm flexion and, unlike the mean elbow angle, is not cancelled out by the pendulum like movements of the arm in both directions (i.e. flexion and extension). Several outliers were identified for the emotions happy, sad and anger. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The Kruskal-Wallis test was significant, $\chi^2(4, N = 159) = 100.99, p < .001$. All
displayed emotion combinations were compared thus 10 post-hoc comparisons were made to see whether the degree of variation in elbow flexion would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. Eight of these post-hoc comparisons reached significance. Happy walkers had greater elbow angle standard deviation than sad, $z(N = 85) = 7.94, p < .001$; fearful, $z(N = 60) = 3.18, p = .001$; and neutral walkers, $z(N = 60) = 5.28, p < .001$. Angry walkers also had greater elbow angle standard deviation than sad, $z(N = 81) = 7.64, p < .001$; fearful, $z(N = 56) = 3.32, p = .001$; and neutral walkers, $z(N = 56) = 5.16, p < .001$. However, there was no significant difference between the elbow angle standard deviation of happy and angry walkers, $z(N = 80) = .38, p = .707$. Sad walkers had less elbow angle standard deviation than fearful walkers, $z(N = 61) = 3.86, p < .001$; and neutral walkers, $z(N = 61) = 3.32, p = .001$. Additionally, there was no significant difference in the elbow angle standard deviation between fearful and neutral walkers, $z(N = 36) = 1.99, p = .046$. Descriptive statistics are shown in Figure 8.13.

The combination of these two conducted kinematic analyses gives a clear indication of how arm movement impacts on the expression, and thus perception of different emotions. Happy and angry walkers exhibited significantly more arm movement whilst fearful walkers and sad walkers exhibited less arm movement. However, fearful and sad walkers showed less arm movement in their walk in different ways. Sad walkers moved their entire arms whilst fearful walkers primarily moved their lower arms throughout their walk.
Figure 8.13. Standard deviation of the right elbow angle (degrees) for walkers displaying each emotion. Error bars depict 95% confidence intervals.

8.3.4.3. Bouncy Gait

Perceivers in both the full-light and point-light walker experiments reported identifying happy walkers by a ‘bouncy gait’ (see Table 8.4). Bouncy gait features were kinematically measured in the point-light walkers through two separate analyses. The first of which is the measurement of the vertical movement of the chest marker. A walker exhibiting a bouncy gait should bounce their whole body with each step. The chest marker is the marker that is least affected by peripheral body movements and thus most suitable for the measurement of torso bounce. It is hypothesised from the perceiver identification strategies that happy walkers will exhibit more vertical movement of the chest marker than walkers displaying the other emotions (i.e. sad, anger, fear and neutral).
As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted to investigate whether happy walkers exhibited more vertical torso movement than the walkers displaying the other emotions (i.e. sad, anger, fear and neutral). The dependent variable for the statistical analysis comprised the mean vertical velocity of the chest marker. Several outliers were identified for the emotions happy and fear. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The Kruskal-Wallis test was significant, $\chi^2(4, N = 159) = 116.42, p < .001$. All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to see whether the walker’s vertical torso movement would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. All except one of these post-hoc comparisons reached significance. Angry walkers had more vertical torso movement velocity than happy, $z(N = 80) = 2.86, p = .004$; sad, $z(N = 81) = 7.63, p < .001$; fearful, $z(N = 56) = 5.88, p = .001$; and neutral walkers, $z(N = 56) = 5.39, p < .001$. Happy walkers also had greater vertical torso movement velocity than sad, $z(N = 85) = 7.62, p < .001$; fearful, $z(N = 60) = 5.81, p < .001$; and neutral walkers, $z(N = 60) = 3.82, p < .001$. Neutral walkers had greater vertical torso movement velocity than sad, $z(N = 61) = 5.65, p < .001$; and fearful walkers, $z(N = 36) = 4.24, p < .001$. However, there was no significant difference between the vertical torso movement velocity of sad and fearful walkers, $z(N = 61) = .35, p = .728$. Descriptive statistics are shown in Figure 8.14.
However, the perceivers may have reported increased bounce, which incorporates a velocity component, in the happy walker’s gaits when they actually meant that the happy walkers exhibited more vertical movement distance. Therefore, a second analysis was conducted on the mean vertical distance of the chest markers of the walkers displaying the different emotions. As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted to investigate whether happy walkers exhibited more vertical torso movement than the walkers displaying the other emotions (i.e. sad, anger, fear and neutral). The dependent variable for the statistical analysis comprised the mean vertical distance travelled by the chest marker. The Kruskal-Wallis test was significant, $\chi^2(4, N = 159) = 109.24, p < .001$. All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to see

![Figure 8.14](image-url)

*Figure 8.14.* Mean vertical movement velocity of the chest marker (represented by Cartesian coordinate changes over time) for walkers displaying each emotion. Error bars depict 95% confidence intervals.
whether the walker’s vertical torso movement would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. All except three of these post-hoc comparisons reached significance. Angry walkers had more vertical torso movement than sad, \(z(N = 81) = 7.48, p < .001\); fearful, \(z(N = 56) = 6.00, p < .001\); and neutral walkers, \(z(N = 56) = 4.97, p < .001\). Happy walkers also had greater vertical torso movement than sad, \(z(N = 85) = 7.24, p < .001\); fearful, \(z(N = 60) = 6.03, p < .001\). Neutral walkers had greater vertical torso movement than sad, \(z(N = 61) = 4.63, p < .001\); and fearful walkers, \(z(N = 36) = 4.68, p < .001\). However, there was no significant difference between the vertical torso movement of happy and angry walkers, \(z(N = 80) = 2.32, p = .020\); and neutral walkers, \(z(N = 60) = 2.78, p = .006\); nor between sad and fearful walkers, \(z(N = 61) = 2.45, p = .014\). Descriptive statistics are shown in Figure 8.15.

However, a bouncy gait may be perceived solely in the way the walker’s feet spring off the ground despite their torso maintaining relatively little vertical movement. A third kinematic analysis was therefore conducted to investigate whether happy walker’s feet sprung off the ground with more speed than the walkers displaying the other emotions (i.e. sad, anger and fear). The heel marker of the right leg (i.e. reference leg) was judged as the most appropriate marker to measure as it represented the accumulation of the force from the ground by the feet. It is well known in kinematic analysis studies that the peak-to-mean velocity ratio is sensitive to the temporal nature of movement and validly describes the shape of the velocity profile (Cooke, Brown, & Cunningham, 1989; Papaxanthis, Pozzo & McIntyre, 2005). A high peak-to-mean velocity score is representative of a relatively large
Figure 8.15. Mean vertical movement distance of the chest marker (represented by Cartesian coordinates) for walkers displaying each emotion. Error bars depict 95% confidence intervals.

change in the velocity over time and may be interpreted as a jerky or bouncy movement whilst a low peak-to-mean velocity score is indicative of a relatively smooth movement. The heel markers upwards peak-to-mean velocity from the ground was therefore calculated separately for a specific phase of each step cycle: the point between the heel markers lowest point and highest point in the Cartesian coordinate space. It is hypothesised from the perceiver identification strategies that happy walkers will exhibit a higher upwards peak-to-mean velocity of the heel marker than walkers displaying the other emotions (i.e. sad, anger, fear and neutral).

An ANOVA was conducted to investigate whether happy walkers exhibited higher upwards peak-to-mean velocity than the walkers displaying the other
emotions (i.e. sad, anger, fear and neutral). For three of the point-light walkers (1 = happy, 2 = anger) the algorithm designed to detect the upward movement prohibited the walkers from meeting the minimum 2-gait cycle requirement and thus were excluded from this analysis. The average upwards peak-to-mean velocity across all step cycles for each walker was used as the data scores. Several outliers were identified for the emotion happy. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The rest of the assumptions of the ANOVA were deemed satisfactory. With alpha set at .05, a significant difference was found, $F(4, 151) = 9.76$, $p < .001$, partial $\eta^2 = .25$, obs. power = 1.00. Post hoc comparisons using the Tukey HSD test revealed that sad walkers exhibited higher upwards peak-to-mean velocity than happy, angry and fearful walkers but not neutral walkers. Descriptive statistics are shown in Figure 8.16.

![Figure 8.16](image_url)

*Figure 8.16.* Mean upwards peak-to-mean velocity ratio of the right heel marker (represented by Cartesian coordinate changes over time) for walkers displaying each emotion. Error bars depict 95% confidence intervals.
These three conducted kinematic analyses give a contrasting indication of how a walker’s bounce in their walk impacts on the expression, and thus perception of different emotions. Angry walkers had the highest vertical bodily movement velocity, followed by happy walkers and then neutral walkers. Sad and fear walkers displayed the lowest vertical bodily movement velocity. Similarly, angry and happy walkers had the largest vertical movement distance, followed by neutral walkers and sad and fearful walkers had the smallest vertical movement distance. However, sad walkers showed a higher upwards peak-to-mean velocity of the right heel marker than the rest of the walkers.

8.3.4.4. Stomping

Perceivers reported identifying anger in particular by stomping movements. This appears to be in direct opposition to the bouncy gait movements reported for happy walkers. The difference between stomping gait movements and bouncy gait movements is conceivably the point in the gait cycle where maximum velocity is reached. In stomping movements the maximum force is directed downwards into the ground and diffused whilst in bouncy gait movements the force is not diffused into the ground but utilised to spring from the ground (i.e. Newtons Third Law). As such, a kinematic analysis was therefore conducted to investigate whether angry walker’s feet descended to the ground with more velocity than the walkers displaying the other emotions (i.e. happy, sad and fear). The heel marker of the right leg (i.e. reference leg) was judged as the most appropriate marker to measure as it allowed direct comparison with the bouncy gait kinematic analysis. As previously argued the peak-to-mean velocity ratio is sensitive to the temporal nature of movement and
validly describes the shape of the velocity profile (Cooke, Brown, & Cunningham, 1989; Papaxanthis, Pozzo & McIntyre, 2005). We therefore calculated the heel markers downwards peak-to-mean velocity towards the ground separately for a specific phase of each step cycle: the point between the heel markers highest point and lowest point in the Cartesian coordinate space. It is hypothesised from the perceiver identification strategies that angry walkers will exhibit a higher downwards peak-to-mean velocity of the heel marker than walkers displaying the other emotions (i.e. happy, sad, fear and neutral).

As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted to investigate whether angry walkers exhibited higher downwards peak-to-mean velocity than the walkers displaying the other emotions (i.e. happy, sad, fear and neutral). For three of the point-light walkers (1 = happy, 2 = anger) the algorithm designed to detect the downward movement prohibited the walkers from meeting the minimum 2-gait cycle requirement and thus were excluded from this analysis. The average downwards peak-to-mean velocity across all step cycles for each walker was used as the data scores. Several outliers were identified for the emotions happy, sad, anger and neutral. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The Kruskal-Wallis test was significant, \( \chi^2(4, N = 156) = 21.39, p < .001 \). All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to see whether the downwards peak-to-mean velocity would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. Only
three of these post-hoc comparisons reached significance. Sad walkers had greater downwards peak-to-mean velocity than happy, \( z(N = 84) = 2.84, p = .004 \); angry, \( z(N = 79) = 3.79, p < .001 \); and neutral walkers, \( z(N = 61) = 3.73, p < .001 \); but not with fearful walkers, \( z(N = 61) = .40, p = .693 \). There was no significant difference in the downwards peak-to-mean velocity between fearful walkers and happy, \( z(N = 59) = 1.14, p = .256 \); angry, \( z(N = 54) = 2.13, p = .033 \); and neutral walkers, \( z(N = 36) = 1.68, p = .094 \). Nor was there a significant difference between happy walkers and angry walkers, \( z(N = 77) = 1.43, p = .153 \); and with neutral walkers, \( z(N = 59) = 1.30, p = .193 \). There was also no significant difference in the downwards peak-to-mean velocity of the heel marker between angry and neutral walkers, \( z(N = 54) = .40, p = .686 \). Descriptive statistics are shown in Figure 8.17.

*Figure 8.17.* Mean downwards peak-to-mean velocity ratio of the right heel marker (represented by Cartesian coordinate changes over time) for walkers displaying each emotion. Error bars depict 95% confidence intervals.
It is clear from these results that angry walkers did not stomp the ground harder than the walkers expressing the other emotions. However, sad walkers did show significantly higher downwards peak-to-mean velocity of the right heel marker than the walkers expressing happy, sad and neutral emotions.

8.3.4.5. Head Turning

Perceivers reported identifying fear by head turning movements. Whilst head turning is strictly speaking a non-gait movement, it can influence the kinematics of the gait. The turning of the shoulders and hips changes the gait kinetics which consequently changes the gait kinematics and is perceivable to perceivers (Jokisch & Troje, 2003; Runeson & Frykholm, 1981, 1983; Westhoff, 2005). Nevertheless, as head turning movements was the most reported identification strategy by perceivers in both the full-light and point-light experiments and the alternative reported identification strategies are contrasting (Table 8.4), a kinematic analysis was conducted on the head turning movements of the point-light walkers. The head turning kinematic was measured by the degree to which the line connecting the left and right ear markers varied from the baseline connecting the two shoulder markers. By doing so, we can distinguish between planar head turning movements and the walker’s body rotation throughout the gait cycle. It is hypothesised from the perceiver identification strategies that fearful walkers will exhibit a higher variation in the degree of planar head turning than walkers displaying the other emotions (i.e. happy, sad, anger and neutral).

As a violation of the homogeneity of variance assumption was found, the nonparametric Kruskal-Wallis test was conducted to investigate whether fearful
walkers exhibited more variation in planar head turning movement than the walkers displaying the other emotions (i.e. happy, sad, anger and neutral). The dependent variable for the statistical analysis comprised the standard deviation of the planar (xy plane: forward, backwards, left, right) angle between the line connecting the right and left ear marker and the baseline connecting the two shoulder markers. The standard deviation of the planar head turning angle is sensitive to the variation in head turning movements and, unlike the mean planar head angle, is not cancelled out by head turning in both directions (i.e. left and right) or influenced by constant off-centre gaze. Several outliers were identified for the emotions happy and anger. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The Kruskal-Wallis test was significant, $\chi^2(4, N = 156) = 21.39, p < .001$. All displayed emotion combinations were compared thus 10 post-hoc comparisons were made to see whether head turning movements would allow the perceivers to use it as an identification strategy for each emotion. Mann-Whitney tests were conducted for these 10 post-hoc comparison with a Bonferroni correction of alpha of .005. Only three of these post-hoc comparisons reached significance. Neutral walkers had less variation in planar head turning movement than happy, $z(N = 60) = 3.87, p < .001$; angry, $z(N = 56) = 3.74, p < .001$; and fearful walkers, $z(N = 36) = 3.51, p < .001$; but not with sad walkers, $z(N = 61) = 2.58, p = .010$. There was no significant difference in the variation of planar head movement between sad walkers and happy, $z(N = 85) = 2.41, p = .016$; angry, $z(N = 81) = 1.71, p = .087$; and fearful walkers, $z(N = 61) = 2.55, p = .011$. Nor was there a significant difference between happy walkers and angry walkers, $z(N = 80) = .87, p = .386$; and with fearful walkers, $z(N = 60) = 1.60, p = .110$. There was also no significant difference in the variation of planar head movement between angry and
fearful walkers, \( z(N = 56) = 1.70, p = .089 \). Descriptive statistics are shown in Figure 8.18.

These results show that fearful walkers did not turn their heads more than the walkers expressing the other emotions. However, the large confidence intervals for fearful walkers, relative to the other displayed emotions (i.e. happiness, sadness and anger), suggests that whilst some fearful walkers did display head turning movements; not enough fearful walkers displayed head turning movements to significantly differ from the planar head movements displayed by the walkers displaying the other emotions. Nonetheless, neutral walkers did show significantly less variation in planar head movement than the walkers expressing happy, anger and fearful emotions.

![Figure 8.18](image)

*Figure 8.18*. The standard deviation of the planar angle (degrees) between the line connecting the left and right ear markers and the baseline connecting the two shoulder markers for walkers displaying each emotion. Error bars depict 95% confidence intervals.
8.4. Discussion

The result of each of the experimental hypotheses is abbreviated in Table 8.5 and will be discussed in the relevant section. Most notable are the two hypotheses that were supported in this experiment. Specifically: a) Perceivers reliably identified significantly above chance each specific emotion displayed by the point-light walkers. b) Fear was identified significantly faster in female point-light walkers than in male point-light walkers. All other hypotheses were not supported in this experiment.

8.4.1. The Identification of Specific Emotions in Walkers

It was hypothesised that perceivers would reliably identify above chance the specific emotion that a walker is displaying through their walking style. As can be seen from Table 8.2, the largest number of perceived emotion categorisations in each distribution is congruent with the emotion displayed by the walker. Furthermore, this effect was found for both male and female walkers (Table 8.3). The findings therefore support the hypothesis that perceivers can reliably identify the specific emotion that a point-light walker is displaying through their walking style. However, the identification of each emotion displayed by point-light walkers (except neutral) appeared to be poorer than for full-light walkers. Additionally, point-light walkers displaying sadness were categorised incorrectly as displaying neutral, fearful point-light walkers were also categorised as displaying sadness, and male happy point-light walkers were also incorrectly perceived as displaying anger significantly above chance, which deviates from the findings of the previous experiment. Each of these findings will be discussed in turn. Congruent with the
Table 8.5

The Result of Each of the Point-light Walker Experimental Hypotheses

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis&lt;sup&gt;ab&lt;/sup&gt;</th>
<th>Result&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification Rates</td>
<td>Emotion &gt; Chance</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Male: Happy and Anger &gt; Sad and Fear</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Female: Sad and Fear &gt; Happy and Anger</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Male: Anger &gt; All other Emotions</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Male Anger &gt; Female Anger</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Female: Happy &gt; All other Emotions</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Female Happy &gt; Male Happy</td>
<td>x</td>
</tr>
<tr>
<td>Identified Emotion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intensity Ratings</td>
<td>Anger &lt; All other Emotions</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Fear &lt; Happy and Sad</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
<td>x</td>
</tr>
<tr>
<td>Identification Times</td>
<td>Happy &lt; All other Emotions</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Anger &lt; All other Emotions</td>
<td>x</td>
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<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Happy and Anger &lt; Sad and Fear</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Anger &gt; All other Emotions</td>
<td>x</td>
</tr>
</tbody>
</table>

<sup>Note</sup>. Some of these hypotheses may appear contradictory because they are derived from opposing arguments or evidence.

<sup>a</sup>"/> denotes the direction of the specific hypothesis. <sup>b</sup>Any expression preceding ':.' pertains to a specific condition applicable to that hypothesis. <sup>c</sup>✓ denotes a supported hypothesis. <sup>d</sup>x denotes an unsupported hypothesis.

findings of the full-light experiment, each emotional category was correctly identified significantly above chance for both male and female walkers (Table 8.3). Thus the specific emotions of happiness, sadness, anger, fear and neutral can be accurately identified through point-light walker displays. However, the pattern of identifications differs between full-light walkers (sad = fear > happy > anger > neutral) and point-light walkers (happy = sad = fear > anger > neutral). Comparing
Tables 8.2 and 7.5 it appears that each emotion, except neutral, was identified poorer in point-light walkers than in full-light walkers.

The pattern of identifications differed between FL walkers (sad = fear > happy > neutral > anger) and PL walkers (happy = sad = fear > anger > neutral). The identification rates for sadness and fear dropped by 25% and 30% respectively in the PL experiment whereas happiness and anger dropped by 10% and 8% respectively. It appears that the perception of sadness and fear in gait is influenced more by display format than the other emotions and thus causing the change in perceiver identification pattern. The perception of sadness and fear specific gait may require more perceivable depth information than the other emotions. The reduced depth information of PL displays was likely compounded by the use of non-translating walkers in this experiment instead of the translating walkers used in the previous FL experiment.

The PL walker identification rates by themselves can be misleading as they differed for each walker gender. Female PL walkers had equivalent identification rates for the different emotions (neutral excepted) which is congruent with the findings of Montepare et al. (1987). However, when the walker was male happiness was identified the best, followed by sadness and then anger but fear was statistically similar to each emotion. Congruent with the results of the previous full-light experiment, anger was identified significantly better in female than male point-light walkers suggesting that the advantage female actors had at expressing anger through their gait (Grossman & Wood, 1993) was retained despite the reduction in perceptual depth information of non-translating PL walkers. However, incongruent
with the previous full-light experiment, happiness, sadness and fear were identified in both genders equally well. It appears that the advantage that female walkers had at expressing their emotions (Grossman & Wood, 1993) in the FL experiment was reduced more so for happiness, sadness and fear by the loss in perceptual depth information of non-translating PL walkers. We originally hypothesised that observers would be perceptually biased towards happiness and fear in female walkers because females, being less able to defend themselves from attack, would be more likely to cower in fear or attempt to facilitate cooperation through displays of happiness. The gender of the walker is less obvious in the point-light stimuli than the full-light stimuli thus the perceptual bias towards happiness and fear in female walkers was lessened in this experiment.

The most likely reason for the drop in correct identifications in point-light walkers is a reduction in the stimuli shown to perceivers. Point-light walkers’ show the perceivers kinematic and some structural information (Cutting et al., 1978) whilst full-light walkers allow the perceivers access to additional structural information (e.g. breasts on female walkers) and non-gait related information (e.g. clenched fists). Point-light stimuli therefore hold less perceptual information than full-light stimuli thus perceivers had access to fewer perceptual cues to distinguish between the different emotions.

The results of this study do however, contradict the findings of Atkinson et al. (2004) who compared emotion identification rates of both full-light and point-light displays. Of the emotions they investigated, only anger and fear were identified significantly better in full-light displays than point-light displays. The current study
found that all emotions, except neutral, were identified better in full-light displays. The different findings between the previously conducted study (Atkinson et al. 2004) and the current study could be the result of using different methods of movement to convey the different emotions. The displays used by Atkinson et al. (2004) depicted actors that were free to express the different emotions as they saw fit which gave rise to a variety of very different movements (i.e. raised hands = fear, jumping = happy). In contrast the actors in the present study were restricted to gait movements. Therefore the perceivers in the study by Atkinson et al. (2004) may have been able identify the different emotions easier because of the greater difference in the type of movements (i.e. jumping vs. raising hands) as opposed to subtle differences within the same movement (i.e. gait). The method of display would therefore have less effect on the identification rates of perceivers in the study by Atkinson et al. (2004) than for the current study. Additionally the same argument could be used to explain Atkinson et al. (2004) found better identification rates for each emotion than the current study for both full-light and point-light displays.

This argument however, is insufficient for our finding that the identification rates for neutral emotion did not significantly differ between full-light and point-light displays. This result could be explained by the argument that neutral was the default choice by perceivers (previously argued in section 7.4.2.2.). That is when perceivers perceived no evident emotion they chose neutral. It is reasonable to predict that a reduction in stimuli information would increase the number of default choices made by perceivers which may have compensated for any legitimate reduction in identifications for neutral emotion (i.e. perceivers chose neutral because
they perceived a normal natural walk). Therefore it is not surprising that neutral had similar identification rates for both full-light and point-light displays.

The reduced stimuli information of point-light display may have also contributed to the three non-hypothesised significant results. That is that point-light walkers displaying fear were mistakenly identified as sad, point-light walkers displaying sadness were misidentified as neutral and happy point-light walkers were misidentified as displaying anger significantly above chance. However, the reduction in stimuli information does not explain why fearful walkers were specifically identified as sad or why sad walkers were identified as neutral or why male happy walkers were identified as angry in particular. It can be seen in the results of the full-light walker study (Table 7.5) that perceiver’s second most frequent categorisation of fearful walkers was sad (after the correct fear) and of sad walkers was neutral (after the correct sad). Additionally, Table 7.5 shows that perceiver’s third most frequent categorisation of happy full-light walkers (after the correct happy and the significant neutral) were anger. Whilst in the full-light experiment perceivers confused happy walkers with neutral walkers, in this point-light experiment there was no such confusion. There must be some form of similar information in the point-light walkers that allows fearful walkers to be confused with sad walkers and sad walkers with neutral walkers. There must also be male walker specific information that also allows male happy walkers to be confused with angry walkers. The reduced point-light stimuli may have augmented this inherent confusion until the incorrect identification rates reached significance level. Furthermore, this confusion is uni-directional.
Fear and sadness are both withdrawal emotions and thus a likely to both embody movements associated with physical and psychological withdrawal. This supposition is supported by Atkinson et al. (2004) who found such similarities in the movements of their actors as they portrayed sadness and fear. Atkinson et al.’s (2004) actors displayed sadness through the drooping of the head, bringing hands to the face, and crossing the arms in front of the body. All of these movements enclose the actor away from the external environment. A drooping head with the hands in front of the face hinders the actor from making eye contact with any surrounding individuals thus creating a barrier to communication with others. In essence the ‘sad’ actor withdraws into themselves. The crossing of arms in front of the body creates a physical barrier between themself and others, similar to Darwin’s (1872/1999) description of the physical display of fear (see section 3.2.). Atkinson et al.’s (2004) actors also portrayed fear through withdrawing movements: cowering away from the camera and raising their hands in front of their face. The slow crouching movements of fearful walkers in the current study may have been confused with the slow slouching movements of the sad walkers because of similar withdrawal movement characteristics. But why were fearful walkers confused as sad walkers but not vice-versa?

Whilst perceivers reported identifying both sadness and fear by a slow walk, fear was also reportedly identified by a faster walk in full-light walkers and by an inconsistent pace in point-light walkers. This duality in perceiver’s reported identification strategies (i.e. slow and fast pace) was previously argued to be a result of the environmental context for experiencing fear (see section 7.4.3.4.). A walker may be cautious of something in the environment and thus walk slow or they may be
fleeing from something in the environment and thus walk fast. Fear therefore can also be identified by a fast or inconsistent walking pace which clearly differs from the lethargic movements used to identify sad walkers. The additional cues for identifying fear in point-light walkers may have precluded sad walkers from being categorised as displaying fear despite fearful walkers being confused with sad walkers. It is still not clear why male happy point-light walkers in particular were mistakenly categorised as displaying anger significantly above chance?

Happiness and anger are both approach emotions and thus a likely to both embody movements associated with physical and psychological approach. Atkinson, et al’s (2004) actors portrayed both happiness and anger with similar behaviours. Anger was expressed by the actors moving towards the camera, jumping and shaking their fists in the air whilst happiness was expressed by jumping up and down and shaking the fists either in front of the body or above the head. The shaking of the fists in the air whilst jumping was congruent to the expressions of both happiness and anger. Furthermore an analysis of the perceiver’s reported identification studies in the current point-light experiment (see Table 8.4) shows that similar movements were used to identify both emotions. Perceivers reported identifying happiness in the current experiment by a fast bouncy gait with increased arm swing whilst anger was reportedly identified by a fast stomping gait with increased arm swing. The distinguishing identification strategy appears to be that a happy gait is bouncy whilst an angry gait involves stomping. Both a bouncy gait and a stomping gait are energetic gait movements therefore it is feasible that they too may be confused with each other. This confusion between the perception of happiness and anger appears to be uni-directional; that is happy point-light walkers
are confused with angry walkers but angry point-light walkers are not confused with happy walkers. However, the second most frequently chosen category for angry point-light walkers was happy though this did not reach statistical significance.

It is also not clear why only male happy walkers are confused as angry. As previously discussed (see section 3.5.1.), male specific gait (Troje, 2002) likely has similar characteristics to anger specific gait. The perceiver ratings of both the full-light experiment (see section 7.4.2.1.) and the present point-light experiment (discussed later in section 8.4.2.1.) show that perceivers were particularly sensitive to the perception of anger in male walkers. Additionally there is sufficient structural information in point-light displays for perceivers to identify the gender of the point-light walker (Cutting et al., 1978). As previously discussed (see section 7.4.2.1) males are more likely to react to a threatening situation with the fight-or-flight response (Trivers, 1985) whereas females are more likely to react with the tend-and-befriend response (Taylor et al., 2000). Males are therefore more likely than females to fight with anger or flee out of fear. Additionally males, typically being stronger than females, are capable of administering more damage to another person when angered. Perceivers are therefore likely to have attuned their perceptual systems to identify the emotion of anger particularly in males due to both previous perceptual experience and the potential for greater harm from angry males (Walk & Homan, 1984). Therefore it is likely that when perceivers perceived an approach emotion in a point-light walker, which embodied similar movement characteristics (i.e. fast gait with a long arm swing); perceivers were more likely to confuse the emotion with another approach emotion. Perceiver’s greater perceptual sensitivity to anger in male point-light walkers may bias perceiver responses in favour of anger if the point-light
walker was perceived to be male. Such an argument therefore explains how male happy walkers can be perceived as displaying anger significantly above chance but not vice-versa.

It is however, still not clear why point-light walkers displaying sadness were mistakenly categorised as displaying neutral significantly above chance. It is possible that the slow lethargic gait movements of sad walkers may be perceived as a normal relaxed walk with no real emotional content (i.e. neutral). Happy and anger are both displayed through energetic movements and fear is displayed through tense movements. It is thus not surprising that walkers displaying sadness are confused with neutral walkers due to the commonalities between lethargic movements and relaxed movements. When this argument is made in conjunction with the previously made argument that neutral was a default strategy for perceivers when no emotional content could be perceived in the walker’s gait (see section 7.4.2.2.), a feasible explanation for the unidirectional confusion can be made. The lethargic movements of a sad walker may have been confused with a relaxed emotionless walk and thus perceivers defaulted to a neutral identification. Consequently sad walkers were confused with neutral walkers statistically above chance but not vice-versa.

The discussed results so far have not supported the alarm hypothesis (Walk & Homan, 1984). However, as with the previous full-light experiment, we will now delve deeper into the data and investigate the perceiver ratings and reaction times for the different emotions with the aim of understanding how the alarm hypothesis (Walk & Homan, 1984) may influence the perception of specific emotions from point-light walkers.
8.4.2. Testing the Alarm Hypothesis in Point-light Walkers

Congruent with the results of the previous full-light experiment perceiver identification rates have not supported the alarm hypothesis (Walk & Homan, 1984). However, perceiver ratings of emotional intensity and emotion identification reaction times are more sensitive measures of emotion perception because they account for different degrees of emotion perception instead of the perceiver’s absolute ability to identify the displayed emotion. We therefore investigated the perceiver ratings of emotional intensity and emotion identification reaction times to get a clearer understanding of how the alarm hypothesis (Walk & Homan, 1984) influenced the perception of basic emotions from gait.

8.4.2.1. Perceiver Ratings of the Intensity of the Emotion Displayed by Point-light Walkers

The findings of this point-light experiment are largely congruent with the findings of the previous full-light experiment. Specifically, perceivers are most attuned to the perception of sadness compared to the other emotions but only in female walkers. Also, perceivers are more attuned to the perception of anger in male walkers compared to female walkers. In contrast to the results of the previous full-light experiment perceivers were more attuned to fear than anger in female point-light walkers.

The alarm hypothesis (Walk & Homan, 1984) predicts that perceivers will be most attuned to the perception of emotions that are important for our survival (i.e. anger followed by fear). The present experiments findings that perceivers are more
attuned to the perception of sadness in female point-light walkers are clearly
contradictory to the alarm hypothesis’ predictions. It was previously argued (see
section 7.4.1.) that females were more skilled at expressing their emotions and thus
perceivers would have less difficulty in perceiving those emotions displayed through
their walking style. However, with the exception of low and high intensity sadness,
male point-light walkers received lower ratings than female point-light walkers for
all emotions at all displayed intensities. It should be noted that only the ratings from
correct identifications were used as the data in this analysis thus a lower rating
indicates a greater sensitivity to the perception of that emotion because a lower
emotional intensity is needed to perceive the emotion. Our results therefore appear
incompatible with our previous argument that females are more skilled at displaying
specific emotions through walking style (see section 8.4.1.). However male walkers,
being less skilled at displaying each emotion, likely displayed each emotion at a
lower intensity than female walkers. Perceivers consequently identified each
emotion at a lower level of displayed intensity. Therefore our perceiver ratings
results likely reflect a difference in the displayed intensity of each emotion by the
walkers instead of a perceptual bias towards distinct emotions in specifically
gendered walkers.

There is an alternative explanation for why sadness had such low perceived
intensity ratings relative to the other emotions. Sadness by definition lacks
enthusiasm and thus is displayed through passive movements (Darwin, 1872/1999).
It has been reported in both full-light and point-light walkers that sadness is
perceived by slow lethargic gait movements. As such when a person becomes
increasingly sad they may be perceived as lacking emotional intensity. This
argument is incongruent with the findings of Atkinson et al. (2004) who found a direct correlational relationship between the perceived ratings of emotional intensity with the emotional exaggeration for every emotion studied (including sadness). However in the study by Atkinson et al., the actors made bigger and faster movements to display more exaggerated sadness which was argued to decrease the accuracy in identifying sadness in point-light displays. Walkers displaying sadness in this study decreased the speed and the size of their gait movements as they increased the intensity of the displayed emotion. As such sadness may have been rated by perceivers as having less emotional intensity simply because a sad walking style lacks intense movements.

The gender of the walker again appears to influence a perceiver’s attunement to the perception of anger and fear in point-light walkers. Congruent with the predictions of the alarm hypothesis (Walk & Homan, 1984), perceivers were most attuned to the perception of anger (after sadness) but only when the point-light walker was male. Additionally, perceivers were also more attuned to the perception of high intensity fear (after sadness) but only when the point-light walker was female. It was hypothesised in this experiment that perceivers would be more attuned to the perception of anger in males because an angry male, due to their increased stature, is capable of accomplishing more physical harm. Ecological theory (Gibson, 1979/1986) would argue that an individual’s visual perception systems would attune to perceive anger in males because of the increased threat to survival. The linked hypothesis predicted that perceivers would be more attuned to the perception of fear in females because females, due to their reduced stature, are less able to defend themselves against attack. Ecological theory (Gibson, 1979/1986)
would also argue that an individual’s visual perceptual systems would have attuned to the perception of fear in females because of the potential for advantage (e.g. resources, social dominance). However, the finding that correctly identified sad walkers were rated as displaying lower emotional intensity precluded both of these hypotheses from being supported. The alarm hypothesis (Walk & Homan, 1984) is therefore not supported.

8.4.2.2. Reaction Times for the Perception of Emotions in Point-light Walkers

The results investigating the perceiver reaction times for identifying the different emotions from point-light walkers are largely congruent with the findings of the previous experiment with full-light walkers. Happiness and anger were identified correctly and incorrectly faster than both sadness and fear. There was no difference in the perceiver reaction times between correctly and incorrectly identified neutral emotion. All other emotions were identified faster when the emotion was identified correctly than when it was identified incorrectly. However, there were two exceptions which deviated from the findings of the full-light experiment; fear was identified faster in female walkers than male walkers and there was no difference in how fast perceivers identified fear correctly or incorrectly when the point-light walker was male.

Due to the congruency between the results of this point-light experiment with the previous full-light experiment; the same arguments can be made to explain both sets of results (see section 7.4.2.2.). The video clips depicting each emotion were significantly shorter for happy and angry walkers than for sad and fearful point-light
walkers. Furthermore, the correlation between the perceiver identification times and the video clip duration indicates that our reaction time results can be largely explained by the video clip duration depicting each emotion. The duration of all walker video clips will therefore be normalised in the next experiment using synthetic walker stimuli. Additionally, the previously found (full-light experiment) weak but significant correlation between the video duration and the emotion identification rates was not found in this point-light experiment. As the strength of the correlation found in the full-light experiment was negligible ($\rho = .181$), the lack of significant correlation in the current point-light experiment is not worrisome.

There was one additional finding in this point-light experiment that deviated from the findings of the previous full-light experiment; perceivers did not identify male walkers displaying fear quicker when correct than incorrect. This finding may be explained by the same argument made in the previous section (section 8.4.2.1.). That is that perceivers may have attuned their visual perceptual systems to perceive fear more in females due to their decreased ability to defend themselves. As such, perceivers required less time to correctly identify fear in point-light walkers when the walker was female than when the walker was male. However, male full-light walkers displaying fear were identified quicker correctly than incorrectly. The failure to replicate this finding with point-light walkers indicates that perceivers had more difficulty in identifying fear in male walkers. The reduction of the full-light stimuli to point-light stimuli may have compounded the perceiver’s difficulty in identifying fear in male walkers. Consequently slowing the perceiver reaction times for correctly identifying fear in male point-light walkers until there is no significant difference between correct and incorrect identifications. The findings of this
experiment appear to support the explanation that fear is easier to identify in female walkers.

So far we have investigated how well perceivers can identify the different emotions as displayed by point-light walkers, perceiver ratings of emotional intensity of the displayed emotion and the perceiver reaction times for identifying the different emotions. However, much understanding of the results can be garnered by investigating the strategies that perceivers used to identify the different emotions displayed through gait. As such the perceiver identification strategies will be discussed in the next section.

8.4.3. Most Commonly Reported Strategies for Identifying Emotions in Point-light Walkers

Perceivers reported the use of some similar and some different strategies to identify the different emotions displayed by point-light walkers as compared to the full-light walkers. The similarities and differences in perceiver identification strategies between the full-light and point-light experiments will be discussed in this section

8.4.3.1. Identification Strategies for Happy Walkers

Congruent with the findings of the full-light experiment, the two most frequently reported strategies for identifying point-light walkers displaying happiness were bouncy gait and increased arm swing. However, the third most frequently reported strategy changed from having the head up in full-light walkers to a faster walk in point-light walkers. There is enough depth information in the display
of full-light walkers to easily perceive whether the head was up or down on the walker. However, the reduced stimuli of point-light display make such depth information more difficult to perceive thus requiring the perceiver to default to a different identification strategy. In this case, the default strategy for identifying happiness in walkers was a faster walking pace. Both Montepare et al. (1987) and Troje (http://biomotionlab.ca/Demos/BMLwalker.html) found that happy walkers walked with a faster pace and thus the findings of this study are in congruence with the findings of past research.

Furthermore, the conducted kinematic analyses showed that happy walkers did indeed walk faster with increased arm swing, relative to sad and fearful walkers which is congruent with the findings of Michalak et al. (2009) though we found no evidence that happy walkers displayed more bounce in their walk than the walkers displaying any of the other emotions. There are two possible explanations for this kinematic finding. Firstly, perceivers may be identifying happiness in walkers by gait cues outside of their conscious awareness and then explaining their perception by drawing upon stereotypically happy gait movements. Accordingly, a happy gait style perceived as bouncy might not have been particularly bouncy in reality. Secondly, our kinematic measure of a bouncy walk did not actually measure the kinematic aspect of walking bounce that perceivers were referring to. At present we do not have enough evidence to make conclusions either way.

8.4.3.2. Identification Strategies for Sad Walkers

Congruent with the findings of the full-light experiment, the two most frequently reported strategies for identifying point-light walkers displaying sadness
were head down and slower walking pace. However, the order of frequency changed between the two experiments. The head down strategy was the most frequently reported strategy when identifying sadness in full-light walkers but the second most frequently reported strategy for point-light walkers. Conversely, a slower walk was the second most frequently reported strategy for full-light walkers but the most frequently reported strategy for point-light walkers. Again, the reduced stimuli of point-light display would have made the depth information required to identify a lowered head on a walker more difficult to perceive.

In the full-light experiment, the third most frequently reported strategy was slumped shoulders which when combined with a lowered head and a slow walking pace, give the illusion of a slow lethargic walking style which evidently is used by perceivers to identify sadness in walkers. However, slumped shoulders were not the third, or fourth most frequently reported strategy in this experiment with point-light walkers. The third most frequently reported strategy was equally shared by less arm movement and a non-linear walking path. Less arm movement is congruent with the slow lethargic movements of a sad walker. A slower walk with short strides will naturally cause the walker to display less arm swing because a walker’s arm swing is used as a counterbalance for the angular momentum of the lower limbs (Kirtly, 2006). A slower walk produces less angular momentum in the lower limbs thus less counterbalancing arm swing is required. Furthermore, the finding that sad walkers displayed a slow walk with a lowered head and less arm swing is congruent with past research (Edgeworth et al. 2008; Michalak et al. 2009; Montepare et al. 1987; and Troje, http://biomotionlab.ca/Demos/BMLwalker.html).
This sad walking style was also supported by our kinematic analyses which showed that sad point-light walkers displayed a slow walking pace (i.e. short slow steps) with relatively little arm movement. Surprisingly, sad walkers were also found to exhibit both a stomping and a bouncy gait however, this can be explained due to a statistical by-product of our dependent variables (i.e. both up and downwards peak-to-mean velocity). Peak-to-mean velocity is a ratio of the maximum velocity divided by the mean velocity throughout the measured phase of the gait cycle. A slow walk exhibits a longer double support phase of the gait cycle (Kirtly, 2006) thus the slow sad walkers also displayed these gait cycle characteristics. During the double support phase of the gait cycle the measured marker displayed no velocity consequently reducing the mean velocity component of the peak-to-mean velocity ratio. The slow sad walker therefore had a relatively larger peak-to-mean velocity ratio in both upward and downward directions than the walkers displaying the other emotions. In this case, the used kinematic measures were registering the prolonged phase of the bouncy support phase confounding the intended indicator for stomping or a bouncy gait.

As far as the author of the current study/thesis is aware of there is no evidence in the literature that sad walkers walked a non-linear path (i.e. equally 3rd most frequently reported identification strategy). A non-linear path referred to walkers snaking their walk instead of walking the most direct straight line. The previously found lateral body sway of sad walkers could generate enough lateral force to cause the walker to deviate from a straight path (Michalak et al. 2009). Furthermore, the passive movements and flaccid muscles that were described by Darwin (1872/1999) could also explain the occurrence of the snaking walk.
Additionally, this researcher did notice during stimulus construction that actors displaying sadness through their gait generally snaked their walk (see section 6.3.2.). A person who does not walk the most direct route to their destination (i.e. the straight line) may be perceived as not having the motivation to reach the destination. When a non-linear walk is seen in conjunction with a slow lethargic walk a perceiver may be inclined to think that the walker does not want to reach the destination at all but is walking anyway. The lack of vitality and goal directed behaviour in a non-linear walk appears to be interpreted by perceivers that the walker is sad.

8.4.3.3. Identification Strategies for Angry Walkers

The most frequently reported strategy to identify anger in both full-light and point-light walkers were a faster walking pace. A faster walking pace appears to be a strong indicator of anger in a walker and is supported by much past research (Chouchourelou et al. 2006; Darwin, 1872/1999; Edgeworth et al. 2008; Montepare et al. 1987). Furthermore, our kinematic analyses showed that angry point-light walkers had the fastest walking pace (i.e. fast long strides) out of the studied emotions.

The second most frequently reported strategy for identifying anger in full-light walkers was when the walkers had their hands clenched. However, the reduced stimuli of point-light display occluded perceivers from seeing if the walker’s hands were clenched or not. Therefore in this point-light experiment perceivers were deprived of an important visual cue of anger in a walker thus causing the third most frequently reported strategy (i.e. stomping) in the full-light experiment to become
the second most frequently reported strategy in this point-light experiment. Despite perceivers reporting stomping movements in angry walkers, our kinematic analyses found no evidence of a stomping gait in angry point-light walkers.

The third most frequently reported identification strategy of anger in point-light walkers was a long arm swing. As was previously described a walker’s arm swing is used as a counterbalance for the angular momentum of the lower limbs (Kirtly, 2006). Therefore a faster walk will produce greater angular momentum in the lower limbs and thus create a longer arm swing. As a faster walking pace appears to be strong indicator of anger in a walker it is not surprising that anger would also be identified by a long arm swing.

8.4.3.4. Identification Strategies for Fearful Walkers

The most frequently reported strategy to identify fear in both full-light and point-light walkers was when the walker looked around them as if to see what might be about to leap out or chase them. This perceptually alert movement is congruent with Darwin’s (1872/1999) description of a person experiencing fear. However, our kinematic analyses found no evidence of fearful point-light walkers turning their heads more so than the walkers displaying the other emotions. It is possible that examples of fearful walkers turning their heads as they walked were rare but was presumably picked up by the majority of the perceivers as an indication of fear. Hence the head turning identification strategy was the most frequently reported identification strategy because it was used by the majority of the perceivers. However, the few examples of head turning in fearful walkers were not enough to
statistically differentiate the head turning kinematics of fearful walkers from walkers displaying the other emotions.

Additional gait movements that were commonly reported in both the full-light and point-light experiments to identify fear in walkers was a faster and a slower walk. However, the order changed between experiments. A faster walk was the second most frequently reported strategy in the full-light experiment but the third in this point-light experiment. In contrast, a slower walk was the third most frequently reported strategy in the full-light experiment but the second in this point-light experiment. As previously discussed, the actors displaying fear through their gait movements interpreted the fearful situation as either something that they may be approaching (i.e. cautious), in which they walked slow, or something that must be fled from and thus they walked fast (see section 6.3.2.). It was also previously argued that perceivers were aware of this duality in fearful contexts and thus perceived the walkers accordingly (see section 7.4.3.4.). Perceivers apparently understood that a fearful walker could have a fast or a slow gait depending on the fear inducing context. However, our kinematic analyses provide an alternative argument. Fearful point-light walkers displayed fast short steps. Walking pace can be increased by increasing the cadence but decreased by shortening the stride length (Kirtly, 2006). If perceivers attended to the walker’s cadence, which was high, then they would be more likely to perceive a faster walk. But if perceivers attended to the walker’s stride length, which was low, then they would perceive a slower walk. Therefore perceivers could accurately identify fear by both a fast and slow walk depending on the particular gait feature they were attending to.
8.5. Conclusion

It has been shown that specific emotions can be accurately and reliably perceived in point-light walkers. It has also shown that each of the emotions (except neutral) were identified equally well in female point-light walkers. However, anger was identified significantly worse than the other emotions (except neutral) in male point-light walkers. Despite some supporting evidence, the majority of the evidence from this point-light experiment has not supported the alarm hypothesis (Walk & Homan, 1984). Additionally, the previous argument that neutral was a default choice for when perceivers could perceive no emotion was also supported in this experiment (see section 7.4.2.2.). Emotion specific point-light gait movements have also been identified for happiness, sadness, anger and fear.
Chapter 9

Experiment 3: Display of Synthetic Walkers

In the previous experiments, walker stimuli were shown to perceivers which still included certain confounding characteristics. The full-light walkers shown in the first experiment gave perceivers access to non-gait information which may have influenced the perception of specific emotions (e.g. clenching of fists, easily identified gender). The point-light walkers shown in the second experiment finetuned the stimuli by reducing the information available to perceivers (e.g. kinematics and bodily structure of the walkers). However, the gender of each walker was likely still perceivable (Cutting et al. 1978) and thus influenced the perception of specific emotions (see section 8.4.). The synthetic walkers shown to perceivers in this experiment further fine tuned the walker stimuli to exclude any structural information that may have been perceived in the point-light walker experiment (e.g. gender, build, height). Thus the synthetic walker stimuli provided only kinematic information to the perceivers. Therefore if perceivers can accurately perceive different emotions in the walking styles of the synthetic walkers then we can conclude that different emotions can be perceived through the kinematics of gait alone.

9.1. Reliability of Walkers

A subsequent aim of this experiment is to fine tune the walker stimuli to create a set of walkers that are reliably categorised as expressing the emotion the walkers intended to express (i.e. identified). Identifications refer to the judgments made by perceivers that are congruent with the specific emotion the walker intended
to display. Walkers that were not reliably identified (i.e. incorrect categorisations) in the previous point-light experiment were deleted from the set of walker stimuli to be used in the synthetic walker construction process. The advantage of only using walkers that were correctly identified is to safeguard against a major criticism frequently raised in association with using actors to portray emotions through movement: it cannot ascertained whether the experimental data reflect the ability of perceivers to accurately perceive the emotional information portrayed in the movement or the ability of the actors to accurately express the emotions in the movement. Using correct categorisations verifies the ability of the actors to express specific emotions through their walking style thus any differences in the data reflect the abilities of the perceivers to identify the emotions expressed through walking style.

Each walker stimulus item was judged to be reliably perceived correctly if the total of all perceiver categorisations were congruent with the displayed emotion more than 25% of the time. Additionally, each reliably perceived walker was required not to be categorised as displaying an incongruent emotion more than 25% of the time ensuring a low level of perceiver confusion between the emotions displayed by the walker. All reliably identified walker stimulus items, i.e. satisfying of the two above criteria, were included in the process for creating synthetic walker stimuli.

9.2. Generation of Synthetic Walkers

Male, female and gender ambiguous synthetic point-light walkers were created using the method described in Troje (2002). The synthetic walkers have the average
structure (e.g. height, build, limb segment ratios) of all male, female and combined (i.e. ambiguous gender) walkers recorded. Male and female synthetic walkers thus only have differing structure and kinematics if they are shared by walkers of the same gender but not of the opposite gender. Ambiguous gendered synthetic walkers (i.e. combined male and female data) are devoid of any gender related information therefore the perception of emotion from walking style in the ambiguous walker is based on kinematics alone. Accordingly, the male, female and ambiguous gendered synthetic walkers have the same body dimensions but differ only in the kinematics of their emotion specific walking style.

The utilisation of Troje’s (2002) methods for generating synthetic walkers will be briefly described. Each trial of each actor walker was originally represented by a time series of postures with each posture represented by a 51-dimensional vector containing the 3-dimensional Cartesian coordinates of each of the 17 markers representing the walker. The postures of all trials of the represented walker (i.e. the different emotional conditions) were aggregated into a single matrix: each posture recorded at one point in time constituted a row (observations) with the 51 entries for the coordinates of all markers (variables). The average posture was computed and fixed the structural information of that actor walker representation. The 51-dimensional data set was reduced by using a Principal Components Analysis (PCA). PCA is a statistical method that decomposes a multivariate data set into essential components (PCs) that are orthogonal to each other and therefore uncorrelated (Jackson, 1991). The first six PCs (hence eigenpostures) recovered 98% of the total variance of the original data set which was deemed sufficient. A basic walker model for each represented walker in each emotion condition was created using the chosen
eigenpostures. That allowed separating the different emotional conditions by basing the creation of a walker model only on the eigenpostures of a particular emotion. All walker stimulus items that were reliably perceived as displaying the actual displayed emotion (happy = 42, sad = 44, anger = 39, fear = 18, neutral = 18) were included in the modelling process. There were therefore 161 basic walker models created.

The basic walker model only encompasses the characteristics of the gait of a walker (e.g. if the left leg is raised for the next step, the left arm swings backward). The timing of the specific movements are not incorporated in the model but are implicitly preserved in the eigenpostures. Note that the eigenpostures correspond to the original observed time series: they are the values of the markers at each point in time in the new coordinate space spanned by the retained eigenpostures. The eigenpostures are therefore not yet suitable as a model since they represent individual trials with for instance a different number of steps. However, walking is essentially a cyclic movement thus the eigenpostures are basically sinusoidals of a single frequency (Troje, 2002). The scores of the first component usually determine the lowest frequency (fundamental frequency) whilst the other components are either the first or second harmonics (i.e. the associated movements repeat twice or three times as fast as the basic movement of the first component). The eigenpostures can therefore be modelled with a sinusoidal determined by three parameters: frequency, phase, and amplitude. Each of the eigenpostures of the basic walker model was forced to conform to a sinusoidal using a Matlab sinewave fitting routine (Moisy, 2006). The resulting full walker model can be sufficiently described in terms of each of the six eigenpostures (each with 51 coefficients, frequency and phase). Note that the amplitude was represented intrinsically in the eigenpostures by
multiplying the original eigenposture with the amplitude. Every original walker trial
could then be described in terms of the respective full walker model with sufficient
accuracy.

However, locomotive walkers display a greater variance in their gait
movements than the treadmill walkers that Troje (2002) used (Westhoff, 2005;
White, Yack, Tucker, & Yin, 1998). As a consequence, components that picked up
similar behaviour were not ordered in the same way across walkers leading to a fatal
degradation in the subsequent steps described below.

We therefore ran a series of correlations for all eigenposture scores across all
walker models to find the walker model that was best correlated to all other walker
models independent of order. The resulting walker model was used as a reference
walker to which each walker model was again correlated against. The individual
eigenposture scores of each walker model were then reordered to maximise the
correlation with the eigenposture scores of the reference walker model\(^1\).
Consequently, the variability across walker models due to individual idiosyncrasies’
in walking styles was confined to within acceptable limits.

\(^1\) Note that since the principal component transformation is a linear transformation, the order of the
components has no specific meaning for the synthesis beyond being conveniently organized
according to the amount of variance in the original data that they recover. This becomes clear if one
considers the inversion of the PCA model (synthesis, Jackson, 1991) as shown in equation 3:

\[ x_k = \hat{x} + Uz_k \]

Where \( x_k \) is the vector with the \( k^{th} \) observations on the original variables, \( \hat{x} \) the vector with the
variable means, \( z_k \) the vector with the \( k^{th} \) observations on the transformed variables (principal
components scores) and \( U \) the matrix containing the eigenvectors as columns. From the equation
above it is evident that the reconstruction leads to exactly the same results if components are
reordered by switching the positions of \( z \) values in the \( z \) value vector and in the same way the
corresponding columns in the \( U \) matrix. This is independent of whether the full principal component
set is used or a subset of components (as is typical for most applications, e.g. to remove noise) by
deleting \( z \)-scores and eigenvectors of components that are of no interest (single values of \( z \) and
columns of \( U \)) before the re-ordering.
Despite the fact that modelling the walkers in this way entails a considerable data reduction, it is still not suitable for the following analysis as in the classification later on there would be still too many model parameters left compared to the relatively low number of observations (for details see Troje, 2002). Accordingly, a further data reduction step was required to form another modelling step:

First, the average walker model was computed from the set of all models. The average walker model was the basis of the synthetic walker since it represents the average of all walker models and therefore the average of all walkers and emotions. Second, the total set of model parameters was subjected to another PCA. The six components (eigenwalkers) retained recovered 68% of the overall variance in the set. Using the chosen subset of the first eigenwalkers, the kinematic features that identify the different emotions in walkers were determined through a Linear Discriminant Analysis (LDA). LDA allows classifying observations according to pre-defined group memberships. More precisely, it determines the axis along which the variance between groups is at its maximum. That means in the case of emotions exhibited by different walking styles, that shifting the kinematic parameter values along this axis would transform a walker from one emotion to another (e.g. a happy walker into a sad walker) or a neutral walker into an emotional walker (e.g. angry walker).

However, because the eigenwalkers constitute another step of abstraction and data reduction (only 68% of the overall variance of the original walker models could be retained), emphasising cyclic over non-cyclic behaviour, the created synthetic
walkers do not have some of the gait features of the point-light walkers used in the previous experiment. Specifically: 1) sad walkers no longer lowered their head nor snaked their walk and 2) the walking pace of fearful walkers was held constant at a moderate pace and no longer showed head turning movements. It can be argued that these features though integral part of the specific gait styles are not strictly gait kinematics in a narrow sense: a lowered head is a static posture, head turns are gestures unrelated to walking and a sneaking gait is path related (even though it has a substantial influence on the gait kinematics in a narrow sense). Since in previous experiments perceivers claimed to identify fearful walkers by inconsistent pace and head turning, the identification rates of fear in the synthetic walkers will likely suffer more so than the other emotions.

In keeping with the aims of our previous experiments, we constructed different intensity levels of emotional expression (i.e. low, moderate and high) for each walker gender. Neutral emotion was the exception because by definition it can only be expressed through a single level of emotional intensity. We therefore constructed 13 synthetic walker stimuli (happy = 3, sad = 3, anger =3, fear = 3, neutral = 1) for each gender (i.e. male, female and ambiguous), totalling 39 synthetic walker stimulus items that were used in this experiment (Appendix H).

9.3. Research Questions

The three research questions investigated in this experiment are identical to the research questions investigated in the previous experiments. The only difference is that in this experiment the questions will relate to the synthetic walker stimuli. As a reminder the research questions are:
1) Can perceivers reliably identify the emotion that a walker is intending to express through their walking style?

2) Is the alarm hypothesis supported when perceiving different emotions through walking style?

3) Does the gender of the walker influence the perception of different emotions through their walking style?

The same independent variables (i.e. displayed emotion, accuracy, intensity, and gender) and dependent variables (i.e. perceived emotion, reaction time, and perceiver ratings) that were used in the previous experiments will also be used in this experiment.

In this experiment, the presented stimuli have been further finetuned to exclude some of the confounding variables that were present in the previous experiments (e.g. bodily structure of the walker). Therefore, despite the lack of support for the majority of the hypotheses in the previous experiments, the same hypotheses were tested in this experiment (abbreviated in Table 9.1). Specifically the following hypotheses were tested in this experiment: 1) Perceivers will reliably identify above chance the specific emotion that a walker is displaying through their walking style. 2) Male synthetic walkers will be perceived as displaying significantly more approach emotions (i.e. happiness and anger) than withdrawal emotions (i.e. sadness and fear). 3) Female synthetic walkers will be perceived as displaying significantly more withdrawal emotions (i.e. sadness and fear) than approach emotions (i.e. happiness and anger). 4) Male synthetic walkers displaying anger will be identified significantly more than any other emotion displayed by male
walkers. 5) Synthetic walkers displaying anger will be identified by perceivers significantly more when the walker is male than when the walker is female. 6) Female synthetic walkers displaying happiness will be identified significantly more than any other emotion displayed by female walkers. 7) Synthetic walkers displaying happiness will be identified by perceivers significantly more when the walker is female than when the walker is male. 8) Perceivers will be able to accurately identify a lower intensity of displayed anger in synthetic walkers than for all other emotions. 9) Perceivers will be able to accurately identify a lower intensity of displayed fear in synthetic walkers than either happiness or sadness. 10) Perceivers will rate correctly identified angry synthetic walkers as expressing a significantly lower level of intensity when the walker is male as compared to female. 11) Perceivers will rate correctly identified fearful synthetic walkers as expressing a significantly lower level of intensity when the walker is female as compared to male. 12) Happiness displayed through walking style will be identified significantly faster than all other emotions. 13) Anger will be identified significantly faster than all other emotions. 14) Anger will be identified significantly faster in male walkers than female walkers. 15) Fear will be identified significantly faster in female walkers than male walkers. 16) Negative emotions will be identified significantly slower than positive emotions. 17) Anger will be identified significantly slower than all other emotions.

9.4. Method

9.4.1. Participants

The sample of perceivers comprised 11 male and 11 female (N = 22) postgraduate psychology students and laboratory employees (from MARCS
Table 9.1

**Abbreviations for Each Hypothesis for this Synthetic Walker Experiment**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis&lt;sup&gt;a,b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification Rates</td>
<td>Emotion &gt; Chance</td>
</tr>
<tr>
<td></td>
<td>Male: Happy and Anger &gt; Sad and Fear</td>
</tr>
<tr>
<td></td>
<td>Female: Sad and Fear &gt; Happy and Anger</td>
</tr>
<tr>
<td></td>
<td>Male: Anger &gt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Male Anger &gt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female: Happy &gt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Female Happy &gt; Male Happy</td>
</tr>
<tr>
<td>Identified Emotion</td>
<td></td>
</tr>
<tr>
<td>Intensity Ratings</td>
<td>Anger &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Fear &lt; Happy and Sad</td>
</tr>
<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td>Identification Times</td>
<td>Happy &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Anger &lt; All other Emotions</td>
</tr>
<tr>
<td></td>
<td>Male Anger &lt; Female Anger</td>
</tr>
<tr>
<td></td>
<td>Female Fear &lt; Male Fear</td>
</tr>
<tr>
<td></td>
<td>Happy and Anger &lt; Sad and Fear</td>
</tr>
<tr>
<td></td>
<td>Anger &gt; All other Emotions</td>
</tr>
</tbody>
</table>

*Note. Some of these hypotheses may appear contradictory because they are derived from opposing arguments or evidence. <sup>a</sup>‘>’ denotes the direction of the specific hypothesis. <sup>b</sup>Any expression preceding ‘:’ pertains to a specific condition applicable to that hypothesis.*

Auditory Laboratories). The sample had a mean age of 26.91 years (SD = 4.61). All perceivers had normal or corrected to normal vision. Informed consent was obtained from each perceiver (Appendix I).

*9.4.2. Materials*
Each of the 39 synthetic walker stimulus items (see section 9.2.) was shown 3 times. The order of the stimuli was randomised with a different order for each perceiver.

The experiment control software Alvin (version 1.19, Hillenbrand & Gayvert, 2005) that was used in the full-light walker and point-light walker experiments was also used in this experiment. The program used was identical to that used in the full-light walker and point-light walker experiments with the exception that perceivers viewed the synthetic walkers created in the first part of this experiment (see section 9.2.).

9.4.3. Design

Because synthetic walkers were created from male, female and combined walker data, an additional level of the gender variable has been added to the statistical analysis: ambiguous gender (see section 9.2.).

9.4.4. Apparatus and Procedure is identical to those used in the full-light walker and point-light walker experiments.

9.5. Results

9.5.1. The Identification of Specific Emotions

As discussed in section 7.3.1., there is a need to control for repeated measures stimulus presentation, observer bias, the overestimation of perceiver performance and incorrect calculations of chance (Wagner, 1993). We therefore converted the raw frequency scores for each perceiver into H_{su} scores with an adjusted level of
chance (i.e. $H_c$) for each cell of the design. The total converted $H_u$ and $H_c$ scores are shown in Table 9.2 and separated by gender in Table 9.3.

Table 9.2

*The Mean $H_u$ Scores of Perceived Emotion Categorisations Compared to the Displayed Emotion of Synthetic Walkers.*

<table>
<thead>
<tr>
<th>Perceived Emotion Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Happy</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>H</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>S</td>
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<td></td>
</tr>
<tr>
<td>A</td>
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<tr>
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<td>F</td>
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<td></td>
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<tr>
<td>N</td>
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<td></td>
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</tbody>
</table>

*Note.* The mean $H_c$ level for each cell is given in corresponding parentheses. * denotes a $H_u$ score that is higher than the corresponding $H_c$ score.

To investigate whether the correct emotion was identified five separate 5 (perceived emotion) x 2 ($H_u$ vs. $H_c$) x 3 (gender) repeated measures ANOVAs were conducted; one for each displayed emotion. All $H_u$ and $H_c$ scores were arcsine transformed for each ANOVA and subsequent post-hoc analyses. Outliers were identified in multiple cells for each of the separate ANOVAs. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of covariance was
### Table 9.3

The Mean Hu Scores of Perceived Emotion Categorisations Compared to the Displayed Emotion of Synthetic Walkers Split by Gender.

<table>
<thead>
<tr>
<th>Displayed Emotion Category</th>
<th>Happy</th>
<th>Sad</th>
<th>Anger</th>
<th>Fear</th>
<th>Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Female Synthetic Walkers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>.330*</td>
<td>.014</td>
<td>.036</td>
<td>.058</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>(.060)</td>
<td>(.059)</td>
<td>(.059)</td>
<td>(.059)</td>
<td>(.020)</td>
</tr>
<tr>
<td>S</td>
<td>.005</td>
<td>.223*</td>
<td>.000</td>
<td>.000</td>
<td>.038*</td>
</tr>
<tr>
<td></td>
<td>(.021)</td>
<td>(.021)</td>
<td>(.021)</td>
<td>(.021)</td>
<td>(.007)</td>
</tr>
<tr>
<td><strong>Perceived Emotion Category</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>.014</td>
<td>.000</td>
<td>.326*</td>
<td>.068</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>(.052)</td>
<td>(.051)</td>
<td>(.051)</td>
<td>(.051)</td>
<td>(.017)</td>
</tr>
<tr>
<td>F</td>
<td>.000</td>
<td>.192*</td>
<td>.010</td>
<td>.192*</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>(.051)</td>
<td>(.050)</td>
<td>(.050)</td>
<td>(.050)</td>
<td>(.017)</td>
</tr>
<tr>
<td>N</td>
<td>.078*</td>
<td>.037</td>
<td>.035</td>
<td>.028</td>
<td>.172*</td>
</tr>
<tr>
<td></td>
<td>(.047)</td>
<td>(.046)</td>
<td>(.046)</td>
<td>(.046)</td>
<td>(.015)</td>
</tr>
<tr>
<td><strong>Male Synthetic Walkers</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>.249*</td>
<td>.010</td>
<td>.057</td>
<td>.041</td>
<td>.032*</td>
</tr>
<tr>
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*Note.* The mean Hu level for each cell is given in corresponding parentheses. * denotes a Hu score that is higher than the corresponding Hu score.
met for the main effect of gender and the interaction HuvsHc x gender in the ANOVAs for the displayed emotions anger, fear and neutral. However, the assumption of homogeneity of covariance was not met for all other main effects and interactions in the five ANOVAs therefore the Greenhouse-Geisser adjustment to the degrees of freedom was used.

The first of the 5 (perceived emotion) x 2 (Hu vs. Hc) x 3 (walker gender) repeated ANOVA was conducted for the displayed emotion of happiness. With alpha set at .05 two main effects were found to be significant: Perceived emotion, $F(1.33, 26.68) = 41.96, p < .001$, partial $\eta^2 = .68$, obs. power = 1.00; HuvsHc, $F(1, 20) = 71.77, p < .001$, partial $\eta^2 = .78$, obs. power = 1.00. However, the main effect of walker gender did not reach significance, $F(1.34, 26.88) = .42, p = .58$, partial $\eta^2 = .56$, obs. power = .11. Of the four possible interactions three were significant: Perceived emotion by HuvsHc, $F(1.20, 23.98) = 47.48, p < .001$, partial $\eta^2 = .70$, obs. power = 1.00; perceived emotion by gender, $F(2.69, 53.73) = 3.06, p = .04$, partial $\eta^2 = .13$, obs. power = .65; and perceived emotion by HuvsHc by gender, $F(2.66, 53.29) = 4.65, p = .01$, partial $\eta^2 = .19$, obs. power = .84. However, the interaction HuvsHc by gender did not reach significance; $F(1.37, 27.38) = .95, p = .37$, partial $\eta^2 = .05$, obs. power = .17. Descriptive statistics are shown in Figure 9.1.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above chance when the synthetic walkers were displaying happiness and thus will not be discussed here. Three of the 10 remaining relevant post-hoc comparisons reached
Figure 9.1. Mean Hu and Hc scores (proportions) for each perceived emotion when happiness was displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.

Happy synthetic walkers were perceived as displaying happiness significantly above chance for female, $t(20) = 6.04$, $p < .05$; male walkers, $t(20) = 6.24$, $p < .05$; and ambiguous gender walkers, $t(20) = 5.32$, $p < .05$. There was no significant difference in how happy synthetic walkers were correctly perceived between female and male walkers, $t(20) = 1.75$, $p > .05$; female and ambiguous walkers, $t(20) = 1.33$, $p > .05$; and male and ambiguous walkers, $t(20) = .44$, $p > .05$. 


Happy synthetic walkers were also not perceived as displaying anger above chance for ambiguous walkers, \( t(20) = 3.29, p > .05 \); and for male walkers, \( t(20) = 2.00, p > .05 \). In addition, happy synthetic walkers were not perceived as displaying neutral emotion above chance for male, \( t(20) = 2.01, p > .05 \); and female walkers, \( t(20) = 3.09, p > .05 \). The results therefore suggest that when a synthetic walker displays happiness then perceivers will also perceive the walker as displaying happiness.

The second 5 (perceived emotion) x 2 (H vs. Hc) x 3 (walker gender) repeated ANOVA was conducted for the displayed emotion of sadness. With alpha set at .05, two of the three main effects were found to be significant: Perceived emotion, 
\[
F(1.88, 37.56) = 25.14, p < .001, \text{ partial } \eta^2 = .56, \text{ obs. power } = 1.00; \text{ H} vs \text{ Hc}, F(1, 20) = 104.77, p < .001, \text{ partial } \eta^2 = .84, \text{ obs. power } = 1.00.
\] 
The main effect of walker gender was not significant, \( F(1.53, 30.59) = 2.52, p < .11, \text{ partial } \eta^2 = .11, \text{ obs. power } = .41 \). Of the four possible interactions two were significant: Perceived emotion by H vs Hc, \( F(1.78, 35.65) = 42.78, p < .001, \text{ partial } \eta^2 = .68, \text{ obs. power } = 1.00 \); and perceived emotion by gender, \( F(2.79, 55.84) = 3.89, p = .02, \text{ partial } \eta^2 = .16, \text{ obs. power } = .78 \). However, the interactions H vs Hc by gender; \( F(1.54, 30.78) = 2.72, p = .09, \text{ partial } \eta^2 = .12, \text{ obs. power } = .44 \), and perceived emotion by H vs Hc by gender, \( F(2.83, 56.59) = 2.84, p = .05, \text{ partial } \eta^2 = .12, \text{ obs. power } = .63 \), did not reach significance. Descriptive statistics are shown in Figure 9.2.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above chance when the synthetic walkers were displaying sadness and thus will not be
Mean Hu and Hc scores (proportions) for each perceived emotion when sadness was displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.

Figure 9.2. Mean Hu and Hc scores (proportions) for each perceived emotion when sadness was displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.

discussed here. Seven of the nine remaining relevant post-hoc comparisons reached significance. Sad synthetic walkers were perceived as displaying sadness significantly above chance for male walkers, $t(20) = 6.64, p < .05$; female, $t(20) =$
Sad synthetic walkers were also perceived as displaying fear significantly above chance in female walkers, $t(20) = 4.07, p < .05$; but not in male, $t(20) = 3.48, p > .05$; or ambiguous walkers, $t(20) = 2.83, p > .05$. There was no significant difference in how sad synthetic walkers were correctly perceived between male and female walkers, $t(20) = 1.33, p > .05$; male and ambiguous walkers, $t(20) = 1.71, p > .05$; and female and ambiguous walkers, $t(20) = .26, p > .05$. The results therefore suggest that when a synthetic walker displays sadness then perceivers will also perceive the walker as displaying sadness. The results also indicate that sad synthetic walkers can be confused as displaying fear but only in female synthetic walkers.

The third 5 (perceived emotion) x 2 (H vs. Hc) x 3 (walker gender) repeated ANOVA was conducted for the displayed emotion of anger. With alpha set at .05, two of the three main effects were found to be significant: Perceived emotion, $F(1.54, 30.75) = 47.53, p < .001$, partial $\eta^2 = .70$, obs. power = 1.00; H vs Hc, $F(1, 20) = 65.83, p < .001$, partial $\eta^2 = .77$, obs. power = 1.00. The main effect of walker gender was not significant, $F(1.96, 39.24) = .58, p = .57$, partial $\eta^2 = .03$, obs. power = .14. Of the four possible interactions one was significant: Perceived emotion by H vs Hc, $F(1.40, 28.01) = 56.58, p < .001$, partial $\eta^2 = .74$, obs. power = 1.00. However, the interactions perceived emotion by gender, $F(2.54, 50.73) = 1.32, p = .24$, partial $\eta^2 = .06$, obs. power = .31. H vs Hc by gender; $F(2, 40) = .30, p = .74$, partial $\eta^2 = .02$, obs. power = .09, and perceived emotion by H vs Hc by gender, $F(2.61, 52.15) = 2.24, p = .10$, partial $\eta^2 = .10$, obs. power = .50, did not reach significance. Descriptive statistics are shown in Figure 9.3.
a) Female

b) Male

c) Ambiguous

Figure 9.3. Mean Hu and Hc scores (proportions) for each perceived emotion when anger was displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not
inform on the investigation of which emotion is perceived significantly above chance when the synthetic walkers were displaying anger and thus will not be discussed here. Three of the seven remaining relevant post-hoc comparisons reached significance. Angry synthetic walkers were perceived as displaying anger significantly above chance for both male, $t(20) = 5.11, p < .05$; female walkers, $t(20) = 6.77, p < .05$; and ambiguous walkers, $t(20) = 6.24, p < .05$. Angry synthetic walkers were not perceived as displaying happiness significantly above chance in ambiguous walkers, $t(20) = 2.21, p > .05$. There was no significant difference in how angry synthetic walkers were correctly perceived between male and female walkers, $t(20) = .84, p > .05$; male and ambiguous walkers, $t(20) = .33, p > .05$; and female and ambiguous walkers, $t(20) = 1.14, p > .05$. The results therefore suggest that when a synthetic walker displays anger then perceivers will also perceive the walker as displaying anger.

The fourth 5 (perceived emotion) x 2 (H vs. Hc) x 3 (walker gender) repeated ANOVA was conducted for the displayed emotion of fear. With alpha set at .05, all three main effects were found to be significant: Perceived emotion, $F(2.33, 46.59) = 10.50, p < .001$, partial $\eta^2 = .34$, obs. power = .99; H vs Hc, $F(1, 20) = 248.59, p < .001$, partial $\eta^2 = .93$, obs. power = 1.00; and walker gender, $F(2, 40) = 5.16, p = .01$, partial $\eta^2 = .21$, obs. power = .80. All four interactions were significant: Perceived emotion by H vs Hc, $F(2.84, 56.84) = 29.35, p < .001$, partial $\eta^2 = .60$, obs. power = 1.00, perceived emotion by gender; $F(3.67, 73.36) = 18.68, p < .001$, partial $\eta^2 = .48$, obs. power = 1.00, H vs Hc by gender; $F(2, 40) = 4.08, p = .03$, partial $\eta^2 = .17$, obs. power = .69, and perceived emotion by H vs Hc by gender,
$F(3.52, 70.40) = 14.98, p < .001$, partial $\eta^2 = .43$, obs. power = 1.00. Descriptive statistics are shown in Figure 9.4.

(a) Female  
(b) Male  

(c) Ambiguous

Figure 9.4. Mean $Hu$ and $Hc$ scores (proportions) for each perceived emotion when fear was displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not
inform on the investigation of which emotion is perceived significantly above chance when the synthetic walkers were displaying fear and thus will not be discussed here. Two of the 11 remaining relevant post-hoc comparisons reached significance. Fearful synthetic walkers were perceived as displaying fear significantly above chance in female, $t(20) = 4.54, p < .05$; but not in male, $t(20) = 2.79, p > .05$; or ambiguous walkers, $t(20) = 2.55, p > .05$. Fearful synthetic walkers were also perceived as displaying sadness significantly above chance in ambiguous walkers, $t(20) = 7.56, p < .05$, and in male walkers, $t(20) = 3.18, p > .05$. Fearful synthetic walkers were not displayed as displaying neutral significantly above chance in male, $t(20) = 3.32, p > .05$; and in ambiguous walkers, $t(20) = 2.17, p > .05$. Female fearful synthetic walkers were not perceived as displaying anger above chance levels, $t(20) = 1.63, p > .05$. There was no significant difference in how fearful synthetic walkers were correctly perceived between male and female walkers, $t(20) = 3.01, p > .05$; male and ambiguous walkers, $t(20) = .42, p > .05$; and female and ambiguous walkers, $t(20) = 2.55, p > .05$. The results therefore suggest that when a synthetic walker displays fear then perceivers will also perceive the walker as displaying fear but only when the walker is female. The results also indicate that fearful synthetic walkers can be confused as displaying sadness in ambiguous gendered synthetic walkers.

The final 5 (perceived emotion) x 2 (H vs. Hc) x 3 (walker gender) repeated ANOVA was conducted for the displayed emotion of neutral. With alpha set at .05, all three main effects were found to be significant: Perceived emotion, $F(1.28, 25.65) = 15.18, p < .001$, partial $\eta^2 = .43$, obs. power = .98; HuvHc, $F(1, 20) = 40.64, p < .001$, partial $\eta^2 = .67$, obs. power = 1.00; and walker gender, $F(2, 40) =$
6.82, \( p < .001 \), partial \( \eta^2 = .25 \), obs. power = .90. All four interactions were significant: Perceived emotion by Huvshc, \( F(1.23, 24.61) = 16.19, p < .001 \), partial \( \eta^2 = .45 \), obs. power = .99, perceived emotion by gender; \( F(2.75, 54.93) = 8.83, p < .001 \), partial \( \eta^2 = .31 \), obs. power = .99, Huvshc by gender; \( F(2, 40) = 6.46, p < .001 \), partial \( \eta^2 = .24 \), obs. power = .87, and perceived emotion by Huvshc by gender, \( F(2.64, 52.73) = 10.15, p < .001 \), partial \( \eta^2 = .34 \), obs. power = .99. Descriptive statistics are shown in Figure 9.5.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of which emotion is perceived significantly above chance when the synthetic walkers were displaying neutral and thus will not be discussed here. Only one of the 11 remaining relevant post-hoc comparisons reached significance. Neutral synthetic walkers were perceived as displaying neutral emotion significantly above chance for female, \( t(20) = 4.68, p < .05 \); but not male walkers, \( t(20) = 2.41, p > .05 \); or ambiguous walkers, \( t(20) = 3.02, p > .05 \). Neutral synthetic walkers were not perceived as displaying anger significantly above chance in male walkers, \( t(20) = 2.42, p > .05 \); as displaying happiness in male, \( t(20) = 2.00, p > .05 \), and ambiguous walkers, \( t(20) = 1.13, p > .05 \); as displaying sadness in female walkers, \( t(20) = 2.22, p > .05 \); and as fear in ambiguous walkers, \( t(20) = 1.40, p > .05 \). There was no significant difference in how neutral synthetic walkers were correctly perceived between male and female walkers, \( t(20) = 3.01, p > .05 \); male and ambiguous walkers, \( t(20) = .42, p > .05 \); and female and ambiguous walkers, \( t(20) = 2.55, p > .05 \). The results therefore suggest that when a synthetic walker
displays neutral emotion then perceivers will also perceive the walker as displaying neutral but only when the walker is female.

a) Female

b) Male

c) Ambiguous

Figure 9.5. Mean Hu and Hc scores (proportions) for each perceived emotion when neutral was displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.

In each of the repeated measures ANOVAs conducted it was found that the emotion displayed was the emotion perceived significantly above chance. However,
this analysis does not show which emotions are perceived better than others. Thus another 5 (Identified emotion) x 2 (Huv vs Hc) x 3 (walker gender) repeated measures ANOVA was conducted for the correctly perceived emotions (see the bolded diagonals of Table 19). With alpha set at .05 all three main effects were found to be significant: Identified emotion, $F(4, 80) = 20.24$, $p < .001$, partial $\eta^2 = .50$, obs. power = 1.00; Huv vs Hc, $F(1, 20) = 113.27$, $p < .001$, partial $\eta^2 = .85$, obs. power = 1.00; and walker gender, $F(2, 40) = 4.38$, $p = .02$, partial $\eta^2 = .18$, obs. power = .72. All interactions were also significant: Identified emotion by Huv vs Hc, $F(4, 80) = 15.37$, $p < .001$, partial $\eta^2 = .43$, obs. power = 1.00; identified emotion by gender, $F(8, 160) = 2.70$, $p = .01$, partial $\eta^2 = .12$, obs. power = .92; Huv vs Hc by gender, $F(2, 40) = 4.30$, $p = .02$, partial $\eta^2 = .18$, obs. power = .72; and identified emotion by Huv vs Hc by walker gender, $F(8, 160) = 2.23$, $p = .03$, partial $\eta^2 = .10$, obs. power = .86. Descriptive statistics are shown in Figure 9.6.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of how well each emotion is relatively identified and thus will not be discussed here. The $Hu$ scores for each emotion were compared with the $Hu$ scores for each other emotion. The post-hoc comparisons were done separately for each walker gender. Only one the remaining 15 relevant post-hoc comparisons reached significance. Happiness was identified significantly better than fear in male synthetic walkers, $t(20) = 4.67$, $p < .05$. However, there was no significant difference between happiness and neutral in ambiguous gendered synthetic walkers, $t(20) = 3.76$, $p > .05$. There was no significant difference in the identification rates of happiness and anger for male, $t(20) = .95$, $p > .05$; female,
$t(20) = .13, p > .05$; and ambiguous gendered walkers, $t(20) = .03, p > .05$. The identification rates for anger was also not significantly different to neutral in female

a) Female  

b) Male

c) Ambiguous

Figure 9.6. Mean $Hu$ and $Hc$ scores (proportions) for identified emotions displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.
synthetic walkers, \(t(20) = 3.43, p > .05\). There was also no significant difference in the identification rates of fear and neutral for male, \(t(20) = 2.06, p > .05\); female walkers, \(t(20) = .45, p > .05\); and ambiguous gendered walkers, \(t(20) = .73, p > .05\). Sadness was not identified significantly different from fear in female walker, \(t(20) = .82, p > .05\); and from happy, \(t(20) = .95, p > .05\); and neutral ambiguous walkers, \(t(20) = 2.81, p > .05\). By comparing these post-hoc comparisons to the descriptive statistics in Figure 9.6, it was concluded that happiness, sadness and anger are identified better than fear and neutral emotion in male walkers. Additionally, happiness and anger were identified better than neutral emotion in female and ambiguous gendered walkers. All other emotions were identified equally well in male, female and ambiguous synthetic walkers.

9.5.2. Testing the Alarm Hypothesis in Synthetic Walkers

9.5.2.1. Perceiver Ratings of the Intensity of the Emotion Displayed by Synthetic Point-light Walkers

A 4 (displayed emotion) x 3 (intensity) x 3 (walker gender) Repeated Measures ANOVA was conducted to investigate whether perceiver ratings of the emotional intensity of synthetic walkers were influenced by the specific emotion displayed by the walker, by the level of displayed emotional intensity and by the gender of the walker. Only perceiver ratings from correct identifications (i.e. displayed emotion = perceived emotion) were used in this analysis. The average correct rating for each perceiver for each cell of the design was used as the data scores. However, some perceivers had multiple missing cells in their data due to their inability to identify the emotion the walker stimulus was displaying.
Furthermore, a missing value analysis indicated the pattern of missing data was not random. Multiple imputation was used to estimate the scores of these missing values and these estimated scores were included in the analysis. Multiple imputation creates multiple data sets that use random samples of the existing data scores to estimate the scores of the missing values. Multiple imputation makes no assumption of a non-random pattern for the missing data whilst still retaining sampling variability (Tabachnick & Fidell, 2001) thus multiple imputation is the preferable method for estimating the missing values in our data set. Ruben (1996) argues that as few as five imputations are necessary to derive confidence valid inferences therefore only five iterations were conducted on our data set. Consequently, identical repeated measures ANOVAs were conducted on each of the five newly created data sets and inferential results were produced by averaging the results of the separate conducted analyses. The expectation-maximization algorithm was used to impute the missing variables for each data set.

Neutral was dropped from this analysis because neutral only has a single level of displayed intensity and was consequently only able to be rated by perceivers as expressing an intensity level of ‘5’ (i.e. most intense score, see section 7.2.2. for more details). Outliers were identified in multiple cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The rest of the assumptions of the ANOVA were deemed satisfactory.

All the main effects and interactions were found to be significant: Displayed emotion, $F(3, 60) = 8.06, p < .05$, partial $\eta^2 = .29$, obs. power = .98; intensity, $F(2,$
40) = 42.83, p < .05, partial $\eta^2 = .67$, obs. power = 1.00; walker gender, $F(2, 19.42) = 19.42$, p < .05, partial $\eta^2 = .49$, obs. power = 1.00; displayed emotion by intensity, $F(6, 120) = 4.39$, p < .05, partial $\eta^2 = .18$, obs. power = .97; displayed emotion by walker gender, $F(6, 120) = 3.44$, p < .05, partial $\eta^2 = .10$, obs. power = .67; intensity by walker gender, $F(4, 80) = 2.66$, p < .05, partial $\eta^2 = .11$, obs. power = .63; and displayed emotion by intensity by walker gender, $F(12, 240) = 3.19$, p < .05, partial $\eta^2 = .14$, obs. power = .99. Descriptive statistics are shown in Figure 9.7.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on how the data may relate to the hypothesised pattern of results (i.e. the alarm hypothesis, Walk & Homan, 1984). Thus the remaining 27 relevant post-hoc comparisons are reported here. It should be noted that the intention of these analyses were to see how each identified emotion was rated by perceivers relative to other identified emotions of the same level of displayed intensity. Therefore, none of the reported post-hoc comparisons contrasted across different displayed intensity levels. Only two of the comparisons reached significance. High intensity fear was rated higher in female walkers than in male, $t(20) = 5.63$, p < .05; or ambiguous walkers, $t(20) = 4.46$, p < .05. None of the remaining post-hoc comparisons reached significance. It should be noted that since the perceiver ratings used in this analysis were only from correct categorisations, a lower rating indicates a greater attunement to the perception of that emotion (i.e. the emotion does not need to be perceived as intense in order to be accurately perceived. The results therefore suggest that
perceivers are more attuned to the perception of fear in male and ambiguous
gendered walkers than in female walkers but only at a high intensity level.

Figure 9.7. Mean ratings of displayed intensity for each identified emotion displayed by: a) female, b) male and c) ambiguous gendered synthetic walkers. Error bars depict 95% confidence intervals.

9.5.2.2. Reaction Times for the Perception of Emotions in Synthetic Point-light Walkers
A 5 (displayed emotion) x 3 (walker gender) Repeated Measures ANOVA was conducted to investigate whether perceiver’s reaction time for identifying each displayed emotion is influenced by the gender of the walker. Only perceiver reaction time scores from when the perceived emotion was congruent with the displayed emotion (i.e. correct identifications) were used in this analysis. The average reaction time of each perceiver for identifying each emotion from each walker gender was used as the data scores. However, many participants failed to make a correct identification in one or more of the conditions thus most cells had missing scores. Furthermore, the pattern of missing scores was found to be non-random. Multiple imputation was used to estimate the values of the missing scores whilst maintaining the variance of each cell in the design (Tabachnick & Fidell, 2001). Five imputations were deemed necessary (Rubin, 1996) thus creating five separate data sets. Separate repeated measures ANOVAs were conducted on each data set and the results were inferred by averaging across the separate analyses. Outliers were identified in multiple cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of covariance was not met for the main effect displayed emotion and for the interaction emotion x gender. The Greenhouse-Geisser adjustment to the degrees of freedom was used where the assumption of homogeneity of covariance was not satisfied. The rest of the assumptions of the ANOVA were deemed satisfactory.

Neither of the two main effects nor the interaction were found to be significant: Displayed emotion, $F(1.48, 29.55) = 2.05, p > .05$, partial $\eta^2 = .09$, obs. power = .35; and gender, $F(2, 40) = 1.03, p > .05$, partial $\eta^2 = .05$, obs. power = .22;
Displayed emotion by gender, $F(1.66, 33.24) = 1.13$, $p > .05$, partial $\eta^2 = .05$, obs. power $= .22$. The results therefore suggest that neither the emotion nor the gender of the walker influenced the time perceiver’s required to identify each displayed emotion.

9.5.3. Most Commonly Reported Strategies for Identifying Emotions in Synthetic Walkers

This section will describe the most pertinent types of movements that perceivers reported to use to identify the specific emotions. For each emotion three movements were predominantly reported by perceivers to identify the specific emotions. Furthermore, these results will be discussed later in comparison to the identification strategies reported by perceivers for full-light and point-light walkers (Table 8.4).

The perceiver identification strategies were coded by four separate researchers and a frequency tally was taken for each identification strategy. The mean frequencies (rounded to nearest integer) across the four coders will be reported here. An intraclass correlation coefficient was calculated for each emotion as a measure of the degree of agreement between the four coders: Happy = .97; Sad = .99; Anger = .94; and Fear = .91.

9.5.3.1. Identification Strategies for Happy Walkers

A total of 59 comments (averaged across the four coders) were made by perceivers, which was divided into 22 separate strategies for identifying synthetic
walkers displaying happiness. The most frequently reported strategy was ‘bouncy gait’ (15/59), followed by ‘faster walk’ (10/59) and then by ‘increased arm movement’ (9/59).

9.5.3.2. Identification Strategies for Sad Walkers

An averaged total of 45 comments were made which was divided into 13 separate strategies for identifying walkers displaying sadness. The most frequently reported strategy was ‘slower walk’ (19/45), followed by ‘less arm movement’ (8/45) and then by ‘shoulders slumped’ (5/45).

9.5.3.3. Identification Strategies for Angry Walkers

An averaged total of 47 comments from 22 different strategies were made by perceivers for identifying anger in synthetic walkers. The most frequently reported strategies were ‘faster walk’ (13/47), ‘stomping’ (7/47), ‘long arm swing’ (5/47).

9.5.3.4. Identification Strategies for Fearful Walkers

An averaged total of 55 comments from 19 different strategies were made by perceivers for identifying fear in synthetic walkers. The most frequently reported strategies were ‘faster walk’ (11/55), ‘slower walk’ (9/55), and ‘inconsistent pace’ (5/55).

9.6. Discussion
The result of each of the experimental hypotheses is abbreviated in Table 9.4 and will be discussed in the relevant section. The hypothesis that perceivers would reliably identify significantly above chance each specific emotion displayed by the synthetic walkers was supported in this experiment. All other hypotheses were not supported in this experiment.

Table 9.4

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis$^{a,b}$</th>
<th>Result$^{c,d}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification Rates</td>
<td>Emotion $&gt;$ Chance</td>
<td>✓</td>
</tr>
<tr>
<td>Male: Happy and Anger $&gt;$ Sad and Fear</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Female: Sad and Fear $&gt;$ Happy and Anger</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Male: Anger $&gt;$ All other Emotions</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Male Anger $&gt;$ Female Anger</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Female: Happy $&gt;$ All other Emotions</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Female Happy $&gt;$ Male Happy</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

**Identified Emotion**

| Intensity Ratings | Anger $<$ All other Emotions | x |
| Male Anger $<$ Female Anger | x |
| Female Fear $<$ Male Fear | x |

| Identification Times | Happy $<$ All other Emotions | x |
| Anger $<$ All other Emotions | x |
| Male Anger $<$ Female Anger | x |
| Female Fear $<$ Male Fear | x |
| Happy and Anger $<$ Sad and Fear | x |
| Anger $>$ All other Emotions | x |

**Note.** Some of these hypotheses may appear contradictory because they are derived from opposing arguments or evidence. $^{a}$ denotes the direction of the specific hypothesis. $^{b}$ Any expression preceding ‘:’ pertains to a specific condition applicable to that hypothesis. $^{c}$ ✓ denotes a supported hypothesis. $^{d}$ x denotes an unsupported hypothesis.
9.6.1. The Identification of Specific Emotions

It was hypothesised that perceivers would reliably identify above chance the specific emotion that a walker is displaying through their walking style. As can be seen from Table 9.2, the largest number of perceived emotion categorisations in each distribution is congruent with the emotion displayed by the walker. Furthermore, this effect was found for both male and female walkers (Table 9.3). The only instance in which the perceiver’s emotion categorisations were not highest with the congruently displayed emotion was in ambiguous gendered walkers where fearful walkers were categorised as displaying sadness more than fear. However, fear was still categorised significantly above chance and received the second highest number of categorisations in the distribution. The findings therefore support the hypothesis that perceivers can reliably identify the specific emotion that a synthetic walker is displaying through their walking style. This finding is congruent with the findings of the previous experiments with full-light and point-light walkers and with other research that have found that emotions can be perceived through bodily movement (Dittrich, et al., 1996; Pollick, et al., 2001) and in particular walking style (Montepare, et al., 1987; Troje, http://www.biomotionlab.ca/Demos/BMLwalker.html). However, the identification of each emotion (except anger) displayed by synthetic walkers appeared to be poorer than for full-light and point-light walkers. Additionally, female sad walkers were incorrectly categorised as displaying fear, and ambiguous gendered fearful walkers were incorrectly categorised as displaying sadness. Each of these findings will be discussed in turn.
The pattern of identifications differed between FL walkers (sad = fear > happy > neutral > anger), PL walkers (happy = sad = fear > anger > neutral) and synthetic walkers (anger = sad = happy > fear > neutral). Compared to the results of the PL experiment the identification rates for synthetic walkers displaying sadness decreased by 6%, fear by 17% and happiness by 9% whereas anger increased by 1%. It appears as if the modelling of the synthetic walkers (see section 9.2.) failed to capture some of the emotion relevant gait information thus hindering perceiver’s ability to distinguish the specific emotions. This is not surprising as the PC-based synthetic walker model only captured 68% of the total movement variance of the original point-light walker models. Whilst this loss of gait information in the synthetic walkers eliminated many of the individual model idiosyncratic gait movements, there was obviously some loss in emotion specific gait information. However, the synthetic walker modelling process also eliminated non-gait specific displays of each emotion (e.g. any example of head turning in fearful walkers; see section 9.2. and Table 8.4) consequently lowering the identification rates for each emotion. The fearful synthetic walkers apparently lost more emotion specific information (i.e. both gait specific and non-gait displays) than the other emotions thus explaining the greater decrease in perceiver identifications for fearful synthetic walkers than the other emotion-displaying synthetic walkers.

However, the synthetic walker identification rates differed according to the gender of the synthetic walker. Female and ambiguous gendered synthetic walkers had equivalent identification rates for the different emotions (except neutral which was identified significantly worse than happiness and anger) which is congruent with the previous point-light experiment and with the findings of Montepare, et al.
However, when the synthetic walker was male happiness, sadness and anger were all identified significantly better than fear and neutral. Apparently the loss of fear-specific gait information was more substantial when only male walkers were included in the synthetic walker creation process (see section 9.2.).

The two non-hypothesised results however, both appear to be linked by the same perceptual confusion mechanism. Female synthetic walkers displaying sadness were mistakenly identified as fearful and ambiguous gendered fearful walkers were misidentified as displaying sadness significantly above chance. The perceiver confusion between the identification of sadness and fear found in the previous PL experiment appears to be exaggerated with the further reduced synthetic walker stimuli. The previously conducted kinematic gait analyses (see section 8.3.4.) found that sad and fearful walkers both showed some similar gait characteristics, specifically; both emotions were displayed through short steps with less arm movement. The similar gait movements for sad and fearful walkers was likely the source of the perceptual confusion between the two emotions thereby causing perceivers to misidentify sad synthetic walkers as fearful and fearful synthetic walkers as sad above chance levels.

The discussed results so far have again not supported the alarm hypothesis (Walk & Homan, 1984). However, as with the previous full-light and point-light experiments, we will now delve deeper into the data and investigate the perceiver ratings and reaction times for the different emotions with the aim of understanding how the alarm hypothesis (Walk & Homan, 1984) may influence the perception of specific emotions from synthetic point-light walkers.
9.6.2. Testing the Alarm Hypothesis in Synthetic Walkers

Congruent with the results of the previous full-light and point-light experiments, the perceiver identification rates did not support the alarm hypothesis (Walk & Homan, 1984). Nevertheless, we investigated more sensitive measures of emotion perception to get a clearer understanding of how the perceptual bias described by the alarm hypothesis (Walk & Homan, 1984) influenced the perception of basic emotions from gait.

9.6.2.1. Perceiver Ratings of the Intensity of the Emotion Displayed by Synthetic Point-light Walkers

None of the hypotheses relating to how the perceived emotional intensity of the synthetic walkers may be influenced by the alarm hypothesis (Walk & Homan, 1984) was supported. This lack of evidential support for the alarm hypothesis (Walk & Homan, 1984) is congruent with the findings of both the full-light and point-light experiments. It therefore appears that perceivers consistently lack a greater attunement to the perception of anger, followed by fear, in walkers.

Contrary to the predictions of the alarm hypothesis (Walk & Homan, 1984), we found that female synthetic walkers displaying fear at high intensity were identified at a significantly higher level of emotional intensity than corresponding male and ambiguous fearful walkers. Requiring more displayed emotional intensity to identify the emotion indicates a lower perceptual attunement to that emotion. However, the alarm hypothesis (Walk & Homan, 1984) predicts that perceivers should be most attuned to the perception of anger, followed by fear, in others due to the immediate
survival enhancing benefits. This argument could be modified for perceiving emotions in female walkers, who due to their reduced stature, are less able to defend themselves against attack and thus more likely to express fear. Ecological theory (Gibson, 1979/1986; McArthur & Baron, 1983), from which the alarm hypothesis (Walk & Homan, 1984) is derived, would argue that perceivers should therefore have adapted and attuned their perceptual systems to perceive fear in females better than in males. However, our findings clearly do not support the alarm hypothesis (Walk & Homan, 1984) or any ecological derivatives specific to the gender of the perceived individual. Nevertheless, our findings in this synthetic walker experiment are largely congruent with the findings of the previous full-light and point-light experiments.

Furthermore, with the exception of perceivers being less attuned to the perception of high intensity fear in female synthetic walker, there were no significant differences in the ratings of emotional intensity of any of the emotions at each level of intensity and for each walker gender. It therefore appears that each emotion was displayed at equivalent levels of emotional intensity for each walker gender except the single aforementioned stimulus item. We can therefore conclude that differences in the identification rates for each emotion from synthetic point-light walkers is due to either a natural predisposition to perceiving certain emotions or due to different degrees of emotional information in the stimulus and not due to different levels of emotional expression.

9.6.2.2. Reaction Times for the Perception of Emotions in Synthetic Point-light Walkers
None of the hypotheses relating to the influence of the alarm hypothesis (Walk & Homan, 1984) on the speed at which each emotion was identified in the synthetic walkers was supported. This lack of evidential support for the alarm hypothesis (Walk & Homan, 1984) is congruent with the findings of both the full-light and point-light experiments. It therefore appears that the speed at which each emotion was identified was not influenced by the alarm hypothesis (Walk & Homan, 1984).

However, we found no significant differences in the perceiver identification times of any of the emotions for either synthetic walker gender, a finding that clearly diverges from the previous full-light and point-light experiments where happiness and anger were identified faster than sadness and fear. In the previous full-light and point-light experiments, the video clips depicting happy and angry walkers were significantly shorter than the corresponding video clips depicting sad and fearful walkers. Furthermore, the video clip durations and the perceiver reaction time data were highly correlated. We previously argued that the difference in the duration of the video clips depicting each emotion best explained the previous perceiver identification time results (see sections 7.4.2.2.). In this present synthetic walker experiment, the duration of the video clips depicting each emotion were normalised. The lack of any significant difference in the perceiver identification times in this experiment strongly supports our previous argument. Evidently, the previous findings that facial displays of different emotions are perceived at different speeds (De Sonneville et al. 2002; Eastwood et al. 2003; Vaughn Becker et al. 2007) can not be generalised to the perception of emotions through locomotive body displays.
The lack of evidential support for the alarm hypothesis (Walk & Homan, 1987) across three experiments (i.e. full-light, point-light and synthetic walkers), and across three different dependent variables (i.e. identification rates, intensity ratings, and reaction time) provides overwhelming evidence to reject the alarm hypothesis (Walk & Homan, 1987) for the perception of emotions in walkers.

6.5.3. Most Commonly Reported Strategies for Identifying Emotions in Synthetic Point-light Walkers

Some but not all of the emotion identification strategies reported by perceivers in this synthetic walker experiment were similar to those reported in the previous point-light experiment. The similarities and differences in perceivers reported identification strategies between the synthetic walker and the point-light walker experiments will be discussed in this section.

9.6.3.1. Identification Strategies for Happy Walkers

Congruent with the findings of the previous point-light experiment, the three most frequently reported perceiver strategies for identifying happiness in synthetic walkers was a fast bouncy gait with increased arm swing. Whilst a bouncy gait was still the most frequently reported perceiver strategy, the order of the 2nd and 3rd most reported strategies switched compared to the point-light experiment. That is a faster walk was the second most reported strategy and increased arm movement was the third most reported strategy. However, as previously argued (see section 8.4.3.3.) a faster walk will also increase the walkers arm movement due to the need to counterbalance the increased forces produced by the legs (Kirtly, 2006) and these increased forces may not be motivated towards an immediate goal (see section
7.4.3.1.). These findings are congruent with past research which has found that happiness is perceived and displayed through a fast bouncy gait (Mikalak et al. 2009; Montepare, et al. 1987; Troje, http://biomotionlab.ca/Demos/BMLwalker.html).

9.6.3.2. Identification Strategies for Sad Walkers

Congruent with the findings of the previous point-light experiment, the two most frequently reported perceiver strategies for identifying sadness in synthetic walkers was a slow gait with decreased arm movement. Two of the identification strategies that perceivers reported to use to identify sadness in point-light walkers could no longer be used with synthetic walkers. As previously discussed (see section 9.2.), the sad gait movements lowered head and a non-linear walking path were eliminated in the synthetic walkers due to the failure to capture all the movement variance of the original point-light walker models. Perceivers were thus denied the opportunity to use these cues consequently causing perceivers to default to other cues of sadness in gait. In this experiment, perceivers defaulted to the reported identification strategy for sadness in full-light walkers: shoulders slumped. As previously discussed (see section 7.4.3.2.), slumped shoulders along with a slow walk with decreased arm movement is reminiscent of the lethargic movements of a sad walking style. The findings of this experiment are therefore congruent with past research (Darwin, 1872/1999; Edgeworth et al. 2008; Michalak et al. 2009; Montepare, et al. 1987; Troje, http://biomotionlab.ca/Demos/BMLwalker.html).

9.6.3.3. Identification Strategies for Angry Walkers
Congruent with the findings of the previous point-light experiment, the three most frequently reported perceiver strategies for identifying anger in synthetic walkers was a fast stomping gait with increased arm swing. However, perceivers reported the use of an additional anger identification strategy for synthetic walkers: arm/leg movements. Stiff arm/leg movements are conceivably the kinematic equivalent of the hands clenched strategy that perceivers reported with full-light walkers. The tight forceful movements of a fast stomping gait are likely to also be perceived as stiff. The findings of this experiment are therefore congruent with past research (Atkinson, et al. 2004; Chouchourelou, et al. 2006; Edgeworth et al 2008; Darwin, 1872/1999; Montepare, et al. 1987).

9.6.3.4. Identification Strategies for Fearful Walkers

The most frequently reported fear identification strategy from the previous full-light and point-light experiments were denied to perceivers in this synthetic walker experiment: head turning. Any displays of head turning that may have been evident in some fearful point-light walkers were totally factored out by the synthetic walker construction process (see section 9.2.) thus denying perceivers access to this non-gait specific cue of fear. However, congruent with the findings of both the previous full-light and the point-light experiments, perceivers reported identifying fear in synthetic walker by both a fast and slow walking pace and likely reflected by the third most frequently reported identification strategy in this experiment (i.e. inconsistent pace). The fearful synthetic walker’s pace was held constant due to the fitting of sinewaves to each walker model’s motion data during the construction of the synthetic walkers (see section 9.2.). Perceivers therefore attempted to distinguish fearful walkers from other emotional walkers by movements that were not evident in
the fearful synthetic walker stimuli, which consequently proved ineffective. The attempted use of ineffective identification strategies by perceivers explains the dramatically reduced identification rates for fear in synthetic walkers from point-light walkers compared to the other emotions. However, the fearful synthetic walker stimuli clearly retained sufficient fear-specific gait information for perceivers to identify the displayed emotion above chance.

9.7. Conclusion

We created a set of synthetically modelled point-light walker stimuli where the emotions happiness, sadness, anger, fear and neutral can be reliably and validly perceived. Furthermore, the expression of each emotion at each level of intensity was displayed equivalently. The synthetic walkers are normalised for form (i.e. bodily structure) and individual idiosyncratic movements have been eliminated. Additionally, a set of gender ambiguous synthetic walkers were created thus eliminating all possible influences of gender on the perception of specific emotions in walking style. Each emotion is therefore displayed solely through the kinematics of the gait movements of the synthetic walkers. Unlike past attempts to create like stimuli (e.g. Troje, http://www.biomotionlab.ca/Demos/BMLwalker.html), our synthetically modelled walkers display each emotion through the ecologically valid movements of translating gait, as opposed to the biomechanically restricted treadmill gait. This synthetic walker stimuli may therefore be used in future emotion perception research on gait as many of the past problems with emotional gait stimuli (e.g. valid, reliable and equivalent perceived emotion expression, influence of gender etc) have been corrected. Congruent with this aim, the next set of
experiments will use these synthetic walker stimuli to investigate the influence of adaptation aftereffects on the perception of specific emotions from gait.
Chapter 10

Experiment 4a: Validating Control Stimulus

In the previous experiments, we have established that the emotions happiness, sadness, anger, fear and neutral can all be perceived from the kinematics of gait. We have also attempted to investigate the perceptual mechanisms that perceivers utilised for this ability. Perceivers reported their identification strategies for each emotion which were subsequently tested through kinematic gait analyses of the point-light walkers. Consequently, key gait features of each emotion expression were identified (see section 8.3.4.). However, walking is a deeply complex bodily movement and perceivers are likely picking up on subtle movement cues that they are not explicitly aware of and we did not test by our kinematic analyses. To obtain a more complete understanding of emotion perception from gait, a deeper analysis of the underlying perceptual mechanisms is needed.

One commonly utilised method for the investigation of the perceptual mechanisms for movement is adaptation aftereffects (Wade, 1994). Adaptation aftereffects are defined as the effect of preceding stimuli to influence the perception of following stimuli (Troje et al. 2006). The classic motion aftereffect was initially described when after observing naturally moving objects in the environment (e.g. rivers, waterfalls) stationary objects appeared to move in the opposite direction (Wade, 1994). The motion aftereffect has since been scientifically investigated in the laboratory setting through perception of novel stimuli (e.g. isoluminance patterns, Cullham et al. 1999; random dot kinematograms, Levinson & Sekular, 1976; Watamaniuk & Heinen, 2007). Furthermore, the classic motion aftereffect can be
generalized to the perception of colour and brightness contrast (Favreau, 1976), velocity (Schrater & Simoncelli, 1998), and the tilting angle of objects (Georgeson, 2004; Greenlee & Magnussen, 1987). The walkers in the previous experiments displayed the different emotions through different walking paces and limb movement angles therefore the perception of emotions from point-light gait is likely susceptible to the velocity and moving angle motion aftereffects.

Indeed, adaptation aftereffects have been found for the perception of more complex biological motion. Jordan et al. (2006) and Troje et al. (2006) both found that neutral gendered point-light walkers were perceived as male after adapting to a female walker and vice-versa. Webster and Maclin (1999) also found that the perceived structure and shape of displayed faces were affected by the previously viewed face. Furthermore, Hsu and Young (2004) found that the perception of facially displayed emotions was influenced by the emotion displayed on the previously viewed face. Thus adaptation aftereffects can be generalised to the perception of emotions and complex biological movements and presumably walking movements. As of yet, adaptation aftereffects have not been tested for the perception of emotions in point-light walkers.

Additionally, adaptation aftereffects can be used to investigate the perceivable relationships between different emotion categories (Rutherford et al. 2008). Unlike simple aftereffects where perception is modified in the symmetrically opposite direction (e.g. left/right, fast/slow), emotional categories don’t have such symmetry. Relational aftereffects between different emotions therefore illuminate the neural and perceptual categories of different emotions. The circumplex model of
emotions (see section 3.1.) will therefore be tested in these subsequent experiments through the use of adaptation aftereffects.

It is likely that the neural relationship between the different perceptual categories of emotions is also represented in the biological motion expressing those emotions. For example, if happy and sad are indeed psychologically opposite then they are likely displayed (and perceived) through opposing biological movements. Emotion perception from biological movements may therefore be related to the simple motion aftereffects previously found in the literature (Cullham et al. 1999; Georgeson, 2004; Greenlee & Magnussen, 1987; Levinson & Sekular, 1976; Schrater & Simoncelli, 1998; Watamaniuk & Heinen, 2007). Consequently, how different emotions are perceived from gait, in addition to the previously found gait movement cues (see section 8.3.4.), can be investigated through adaptation aftereffects. Adaptation aftereffects therefore appear to be suitable for the investigation of the mechanisms underlying emotional gait perception.

However, before we can investigate whether each emotion produces adaptation aftereffects in the perception of other emotions displayed by point-light walkers, we must verify that a neutral walker produces no adaptation aftereffects in the identification of other emotional walkers. Once the absence of adaptation aftereffects after viewing a neutral walker has been verified, the neutral walker can be used as a baseline to which each other investigated aftereffect can be statistically compared.
The aim of this experiment is to verify that a walker displaying a neutral emotion does not produce aftereffects in the identification of subsequently shown walkers displaying different emotions (i.e. happy, sad, anger & fear). It is predicted that, compared to a screen of visual noise, a neutral walker will not produce significantly different identification rates, perceived emotional intensity ratings, nor perceiver identification times for the emotions displayed by subsequently shown walkers.

10.1. Method

10.1.1. Participants

The sample of perceivers comprised 7 male and 7 female (N = 14) postgraduate psychology students (from the University of Western Sydney). The sample had a mean age of 26.79 years (SD = 3.17). All perceivers had normal or corrected to normal vision. Informed consent was obtained from each perceiver (Appendix J).

10.1.2. Materials

For the purposes of the current and subsequent experiments, a single synthetic walker for each emotion must be selected. These selected synthetic walkers act as the stimuli in this and the following experiments and thus it is paramount to select the stimuli that each emotion was optimally identified with. The highest level of emotional intensity should theoretically be the easiest for perceivers to identify which emotion is displayed. We therefore, isolated the synthetic walker identifications of each perceiver for a high level of emotional intensity for ambiguous gendered walkers thus distinguishing these statistical analyses from the analyses conducted in the previous experiment (see section 9.5.1.). We then converted the scores to Hα scores with the corresponding Hc scores (Wagner, 1993).
Each identified emotion (Hₜ) was compared to the corresponding chance level (Hₑ) through planned paired sample t-tests with a Bonferroni correction of alpha of .01. An outlier was identified in a single cell. The outlier was reduced to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). Each emotion was identified significantly above chance: happy, $t(20) = 5.01, p < .001$; sad, $t(20) = 3.61, p = .002$; anger, $t(20) = 5.95, p < .001$; fear, $t(20) = 2.96, p = .008$; and neutral, $t(20) = 3.52, p = .002$. These five stimulus items are therefore suitable for use in the following experiments.

The stimuli shown to perceivers (Appendix K) were displayed in pairs. The first of the pair (i.e. adapting stimulus) was either a neutral walker or a screen of visual white noise (i.e. randomly appearing dots). The second of the pair (i.e. target stimulus) was a synthetic walker displaying 1 of 4 specific emotions (i.e. happy, sad, anger, fear). All stimuli were shown for duration of 6 seconds with a 1 second interval between the stimuli in each pair. A text box displaying “Next Stimulus Pair” separated each pair of stimuli. All pairs of stimuli were shown six times in a fully randomised order.

The experimental control software Alvin (version 1.19) was again used to show walkers to perceivers and subsequently record their emotion identifications and their emotion intensity ratings displayed by the each walker.

10.1.3. Procedure

The procedure was the same as that used in experiments 1, 2, and 3 but with a few modifications. The perceivers were told they would view pairs of stimuli; the
first being either a point-light walker or a screen of snow and the second stimulus would always be a point-light walker. The perceivers were told they were only required to identify the emotion displayed by the second shown walker. The perceivers were still required to rate the intensity of the emotion they perceived in the walker. However, they were not required to complete the open ended questionnaire (Appendix E) that was completed in the previous experiments.

10.2. Results

10.2.1. Perceiver Identifications

Each perceiver’s raw frequency scores for each cell of the design were converted to $H_u$ scores to control for repeated measures stimulus presentation, observer bias, and the overestimation of perceiver performance and then the scores were arcsine transformed for the purpose of these analyses (Wagner, 1993). Only correct perceiver identifications were statistically analysed. Mean $H_u$ scores for each identified emotion after each adapting stimulus are shown in Figure 10.1. Outliers were detected in several cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of normality was violated in two cells thus the non-parametric Wilcoxon Signed-Rank test was performed comparing the $H_u$ scores for each identified emotion after viewing the visual noise and after viewing the neutral walker. Paired-sample T-tests were performed on the two comparisons where the assumption of normality was satisfied. A Bonferroni corrected alpha of 0.0125 was used for each comparison.
There was no significant difference in the Hu scores for each identified emotion after viewing a screen of visual noise compared to after viewing a neutral walker: Happy, $t(13) = 1.65, p = .123$; Sad, $z(N=14) = -1.26, p = .209$; Anger, $t(13) = 1.93, p = .075$; and Fear, $z(N=14) = -3.57, p = .721$. A neutral walker therefore does not produce adaptation aftereffects in the perception of emotions in subsequently shown point-light walkers.

10.2.2. Perceiver Ratings of Emotional Intensity

The average perceiver rating of emotional intensity for each identified emotion for each perceiver were used as the data scores in a series of paired sample T-tests. The perceiver ratings for each identified emotion after viewing a neutral walker was compared with the ratings after viewing a screen of visual noise thus four paired sample T-tests were conducted. A Bonferroni corrected alpha of 0.0125 was used for
each comparison. Outliers were identified in several cells and were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). Some perceivers failed to identify the displayed emotion correctly thus there were missing scores in some cells. When a perceiver failed to identify the displayed emotion then both of their ratings scores (i.e. after adapting to a neutral walker and visual noise) were deleted from the analysis. All other statistical assumptions were satisfied. Mean perceiver ratings for each identified emotion after viewing each adapting stimulus are shown in Figure 10.2.

![Figure 10.2](image)

Figure 10.2. Mean ratings of perceived emotional intensity for each identified emotion after viewing either a neutral walker or a screen of visual noise. Error bars depict 95% confidence intervals.

There was no significant difference in the mean perceiver ratings for each identified emotion after viewing a screen of visual noise compared to after viewing a neutral walker: Happy, \( t(12) = .951, p = .360 \); Sad, \( t(10) = 1.337, p = .211 \); Anger, \( t(13) = -.205, p = .841 \); and Fear, \( t(7) = -1.692, p = .134 \). A neutral walker therefore
does not produce adaptation aftereffects in the perceived emotional intensity in subsequently shown point-light walkers.

10.2.3. Perceiver Reaction Time for Identifying Emotions

The average perceiver reaction times for identifying each emotion for each perceiver were used as the data scores in a series of paired sample T-tests. The perceiver emotion identification reaction times after viewing a neutral walker was compared with the reaction times after viewing a screen of visual noise thus four paired sample T-tests were conducted. A Bonferroni corrected alpha of 0.0125 was used for each comparison. Some perceivers failed to identify the displayed emotion correctly thus there were missing scores in some cells. When a perceiver failed to identify the displayed emotion then both of their reaction time scores were deleted from the analysis. All other statistical assumptions were satisfied. Mean perceiver ratings for each identified emotion after viewing each adapting stimulus are shown in Figure 10.3.

There was no significant difference in the mean perceiver reaction times for displayed sadness after viewing a screen of visual noise compared to after viewing a neutral walker, \( t(10) = 1.690, p = .122 \). However, each other emotion was identified quicker after viewing a neutral walker than after viewing a display of visual noise: Happy, \( t(12) = 3.517, p = .004 \); Anger, \( t(13) = 4.109, p = .001 \); and Fear, \( t(7) = 3.574, p = .009 \). A neutral walker therefore appears to produce facilitation adaptation aftereffects in the perception of happiness, anger and fear in subsequently shown point-light walkers.
The hypothesis that there would be no significant difference in the perceiver identification rates of specific emotions or in the perceived emotional intensity of those emotions in walkers after viewing either a screen of visual noise or a neutral walker was supported. However, the hypothesis that there would be no significant difference in the perceiver reaction times for identifying each emotion in walkers after viewing either a screen of visual noise or a neutral walker was not supported. The finding that perceivers identified happy, angry and fearful walkers faster after viewing a neutral walker is surprising. Especially when a neutral walker does not produce adaptation aftereffects in the identification rates nor the perceived emotional intensity of emotions displayed in point-light walkers. Perceivers may have been able to identify each emotion faster after viewing a neutral walker simply by a comparison of the relatively different gait kinematics of the subsequently

Figure 10.3. Mean perceiver identification reaction times (ms) after viewing either a neutral walker or a screen of visual noise. Error bars depict 95% confidence intervals.

10.3. Discussion

The hypothesis that there would be no significant difference in the perceiver identification rates of specific emotions or in the perceived emotional intensity of those emotions in walkers after viewing either a screen of visual noise or a neutral walker was supported. However, the hypothesis that there would be no significant difference in the perceiver reaction times for identifying each emotion in walkers after viewing either a screen of visual noise or a neutral walker was not supported. The finding that perceivers identified happy, angry and fearful walkers faster after viewing a neutral walker is surprising. Especially when a neutral walker does not produce adaptation aftereffects in the identification rates nor the perceived emotional intensity of emotions displayed in point-light walkers. Perceivers may have been able to identify each emotion faster after viewing a neutral walker simply by a comparison of the relatively different gait kinematics of the subsequently
shown emotional walkers. However, after viewing visual noise the perceivers were denied a non-emotional gait template to which to compare the subsequently shown emotional walker thus needing longer to identify the displayed emotion. In the next experiment the neutral walker can thus be used as a statistical baseline to which the perceiver identification rates and intensity ratings of each tested emotion aftereffect can be compared. However, the neutral walker is not suitable as a statistical baseline comparison for the perceiver identification time data. Therefore more complex statistical procedures are needed to investigate the influence of displayed emotional walkers on the time required for perceivers to identify the emotion displayed in subsequently shown walkers.
In this experiment the influence of possible adaptation aftereffects on the perception of specific emotions from walking style were directly investigated. Additionally, this experiment investigated whether any adaptation aftereffects found could be explained by low level or high level visual processing.

11.1. Low vs. High Level Processing

Hsu and Young (2004) investigated whether the adaptation aftereffects they found for the perception of specific emotions from facial expressions were due to high level processing or whether they were merely a low level phenomenon. Low level visual processing is defined as recognising an object based on the individual features of the object e.g. velocity of a single point-light. High level visual processing is defined as recognising an object based on the relations between low level features e.g. arm swing relation to leg step. High level visual processing therefore requires a certain amount of knowledge about the low level features of the perceived object (Johnson & Olshausen, 2003).

Hsu and Young (2004) found significant adaptation aftereffects when the size of the adapting face was incongruent with the size of the target face. In order for adaptation aftereffects to occur there must be certain degree of similarity between the adapting stimulus and the target stimulus (e.g. the same individuals face, Leopold, Rhodes, Muller & Jeffery, 2005). Altering the size of the adapting face from the size of the target face changes the low level properties of the face but
maintains the high level properties. Hsu and Young therefore determined that low level visual processing could not entirely explain the aftereffects they found because incongruent facial size between the adapting facial expression and the target facial expression still produced significant adaptation aftereffects. The relation between facial features therefore contributed to the adaptation aftereffects and not merely the influence of individual low level features.

Likewise, Atkinson (in press) found the perception of emotion from point-light displays of various bodily actions partially relied on high level visual processing thus suggesting that the findings of Hsu and Young (2004) may be generalised to whole body movements. We therefore, in addition to determining the presence of adaptation aftereffects in the perception of specific emotions from walking style, sought to determine if any adaptation aftereffects found are due to low level or high level visual processing. The size of the walkers shown to perceivers was manipulated to determine if any aftereffects found could be explained by the relation of the point-lights representing the walker (i.e. high level processing) or solely by the individual features of the walkers such as the velocity of an individual point-light (i.e. low level processing).

The aim of this experiment is to see if the inhibition and facilitation effects found for the perception of happiness, sadness and fear from facial expressions (Hsu & Young, 2004) are also supported for the perception of specific emotions in walking style. Furthermore, this experiment will also investigate the influence of adaptation aftereffects on the perception of anger displayed through walking gait.
11.2. Method

11.2.1. Research Question

Do adaptation aftereffects influence the perception of specific emotions from walking style?

11.2.2. Hypotheses

The above research question will be addressed through several specific hypotheses (abbreviated in Table 11.1). Firstly, it is predicted that perceivers will correctly identify walkers displaying a specific emotion (i.e. happy, sad, anger, and fear) significantly less after viewing a walker showing the same emotion than after viewing a neutral walker. It is also predicted that perceivers will correctly identify walkers displaying a specific emotion (i.e. happy, sad, anger, and fear) significantly more after viewing a walker showing a theoretically opposite emotion (e.g. happy/sad, anger/fear) than after viewing a neutral walker. These predictions are consistent with the adaptation aftereffects that Hsu and Young (2004) found for the perception of specific emotions from facial expressions and with Troje et al.’s (2006) finding of adaptation aftereffects for the perception of gender from walking kinematics.

However, adaptation aftereffects might not be strong enough to change the identification of an emotion by a perceiver. Adaptation aftereffects may influence the perceived displayed intensity of each emotion in walkers. Therefore, it is predicted that perceivers will rate identified walkers displaying each emotion as less intense after viewing a walker displaying the same emotion than after viewing a neutral walker. It is also predicted that perceivers will rate identified walkers
displaying each emotion as more intense after viewing a walker displaying the theoretically opposite emotion (e.g. happy/sad, anger/fear) than after viewing a neutral walker.

Table 11.1
Abbreviations for Each Hypothesis Tested in this Adaptation Aftereffect Experiment

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Hypothesis</th>
</tr>
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<tr>
<td>ID Rates</td>
<td>Happiness: Adapting Happy &lt; Adapting Neutral Walker</td>
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<td>Happiness: Adapting Sad &gt; Adapting Neutral Walker</td>
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<tr>
<td></td>
<td>Fear: Adapting Anger &gt; Adapting Neutral Walker</td>
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<tr>
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<tr>
<td></td>
<td>Fear: Adapting Anger &lt; Adapting Other Emotions</td>
</tr>
</tbody>
</table>

aID is an abbreviation for identification. b=/</> denotes the direction of the specific hypothesis. cAny expression preceding ':' pertains to the specific identified emotion applicable to that hypothesis.
It is assumed in these proposed experiments that perceivers will take longer to categorise the emotion a walker is displaying if they have increased difficulty in identifying that emotion. This assumption is supported by the results of experiments 1 (full-light walkers) and 2 (point-light walkers) where perceivers took considerably longer to make incorrect categorisations than correct categorisations. Furthermore, the previous experiment (experiment 4a) found that the neutral walker produced reaction time aftereffects in the perception of subsequently shown walkers displaying happiness, anger and fear. The neutral walker is thus only suitable as a statistical baseline for investigating the time perceivers required to identify sadness. The time required for identifying happiness, anger and fear must therefore be statistically compared across adapting conditions. It is therefore predicted that after viewing a walker displaying a specific emotion (i.e. happy, anger, and fear), perceivers will take significantly longer to correctly identify a walker displaying the same emotion than after viewing a walker displaying a different emotion. Additionally, it is predicted that perceivers will take significantly longer to correctly identify a walker displaying sadness after viewing a walker also displaying sadness than after viewing a neutral walker. It is also predicted that after viewing a walker displaying a specific emotion (i.e. happy, anger, and fear), perceivers will take significantly less time to correctly identify a walker displaying a theoretically opposite emotion than a walker displaying a different emotion. Additionally, it is predicted that after viewing a walker displaying sadness, perceivers will take significantly less time to correctly identify a walker displaying happiness (i.e. the theoretically opposite emotion) than a neutral walker.
Lastly, it is predicted that adaptation aftereffects will be found for the perception of specific emotions from walking style for both small and normal-sized walkers. This prediction is consistent with Hsu and Young’s (2004) finding that low level visual processing could not entirely explain the adaptation aftereffects they found for the perception of specific emotions from facial expressions.

11.2.3. Participants

The sample of perceivers comprised 6 male and 27 female (N = 33) first year psychology students (from the University of Western Sydney) in return for course credit. The sample had a mean age of 21.42 years (SD = 4.18). All perceivers had normal or corrected to normal vision. Informed consent was obtained from each perceiver (Appendix L).

11.2.4. Materials

The synthetic walkers that were used as target walkers in experiment 4a were also used in this experiment. Also, each type of synthetic walker comprised the adapting stimuli in this proposed experiment. Additionally, the neutral walker was also used as an adapting stimulus to which other emotion displaying adapting walkers could be statistically compared. Furthermore, the adapting synthetic walkers were shown in 1 of 2 sizes (i.e. small or normal-sized). Small walkers were identical to the normal-sized walkers in every way except that the small walkers were half the size of the normal-sized walkers. There were thus 10 adapting walkers (i.e. small and normal-sized: happy, sad, anger, fear and neutral) and four target walkers (i.e. happy, sad, anger and fear; Appendix M). All possible combinations of adapting
walkers followed by target walkers were shown to perceivers three times in a randomised order with each perceiver being shown a different order.

The experimental control software Alvin (version 1.19, Hillenbrand & Gayvert, 2005) was again used to show walkers to perceivers and subsequently record their emotion identifications, their emotion intensity ratings and their reaction times for identifying the emotion displayed by each walker.

11.2.5. Procedure

The procedure was the same as that used in experiment 4a but with a single modification. The perceivers were told they would see pairs of point-light walkers displaying specific emotions and they were required to identify the emotion displayed by the second walker in the pair. The perceivers were still required to rate the intensity of the emotion they perceived in the walker.

11.3. Results

11.3.1. The Identification of the Emotion Displayed by the Target Synthetic Walker

Each perceiver’s raw frequency scores for each cell of the design was converted to Hu scores to control for repeated stimulus presentation, observer bias, and the overestimation of perceiver performance and then the scores were arcsine transformed for the purpose of these analyses (Wagner, 1993). Only correct perceiver identifications were statistically analysed. Mean Hu scores for each identified emotion after adapting to each emotion of both small and normal-sized walkers are shown in Figure 11.1. Outliers were detected in several cells. The outliers were reduced/increased to within one unit of the next most extreme score in
a) Normal-sized Adapting Walker

![Graph showing mean perceiver Hu scores (proportions) for each identified emotion after adapting to a normal-sized walker.]

b) Small Adapting Walker

![Graph showing mean perceiver Hu scores (proportions) for each identified emotion after adapting to a small walker.]

Figure 11.1. Mean perceiver Hu scores (proportions) for each identified emotion after adapting to a a) normal-sized walker or b) small walker displaying each emotion. Error bars depict 95% confidence intervals.

In the previous experiment (see section 10.2.1.), we found that adapting to a neutral walker produced no adaptation to the cell (Tabachnick & Fidell, 2001). In the previous experiment (see section 10.2.1.), we found that adapting to a neutral walker produced no adaptation.
aftereffects in the identification of subsequently shown emotional walkers. The neutral walker is therefore suitable to be used as a statistical baseline to which the perceiver identification rates of each emotion aftereffect can be compared. Paired-sample T-tests were performed comparing the Hu scores for each identified emotion after viewing a normal-sized neutral walker and after viewing normal-sized walker displaying a specific emotion (i.e. happy, sad, anger, fear). Similar paired-sample T-tests were performed again but comparing the Hu scores for each emotion after adapting to a normal-sized neutral walker and after adapting a small walker displaying a specific emotion. Hence, 32 paired sample T-tests were conducted with an alpha of .05 and a Scheffe correction for multiple comparisons. Only 2 of the T-tests reached significance. The Hu scores for identifying anger were significantly lower after adapting to an angry walker than after adapting to a neutral walker of the same size, t(32) = 3.04, p = .005. Also, the Hu scores for identifying fear were significantly higher after adapting to an angry walker than after adapting to a neutral walker of the same size, t(32) = 3.47, p = .002. Therefore, after adapting to an angry walker perceivers identification of anger was inhibited but the identification of fear was facilitated.

11.3.2. Perceiver Ratings of the Intensity of the Emotion Displayed by the Target Synthetic Walkers

The average rating of emotional intensity for each identified emotion after viewing each adapting emotion for each perceiver were used as the data scores for statistical analysis. Many perceivers failed to correctly identify the emotion in one or more of the cells. A missing value analysis of the data showed that the pattern of missing values was not random. Multiple imputation with five iterations (Ruben,
1996) was used to estimate the scores of these missing values and these estimated scores were included in the analysis. Identical dependent sample t-tests were conducted on each data set and inferential results were produced by averaging the results of the separate analyses conducted on the five separate data sets. The expectation-maximization algorithm was used to impute the missing variables for each data set. Outliers were identified in multiple cells. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The rest of the assumptions of the dependent sample t-tests were deemed satisfactory. Mean perceiver ratings for each identified emotion after each adapting condition can be seen in Figure 11.2.

In the previous experiment (see section 10.2.2.), we found that adapting to a neutral walker produced no adaptation aftereffects in the perceiver ratings of displayed emotional intensity of subsequently shown emotional walkers. The neutral walker is therefore suitable to be used as a statistical baseline to which the perceiver intensity ratings of each emotion aftereffect can be compared. Paired-sample T-tests were performed comparing the mean emotion intensity ratings for each identified emotion after viewing a normal-sized neutral walker and after viewing normal-sized walker displaying a specific emotion (i.e. happy, sad, anger, fear). Similar paired-sample T-tests were performed again but comparing the intensity ratings for each emotion after adapting to a normal-sized neutral walker and after viewing a small walker displaying a specific emotion. Hence, 32 paired sample T-tests were conducted on each data set with an alpha of .05 and a Scheffe correction for multiple comparisons. None of the T-tests reached significance. Adapting to either a small or
a normal-sized walker displaying an emotion did not produce aftereffects in the perceived emotional intensity of subsequently displayed walkers.

a) Normal-sized Adapting Walker

![Bar graph showing mean ratings of perceived emotional intensity for different emotions after adapting to a normal-sized walker. Error bars depict 95% confidence intervals.]

b) Small Adapting Walker

![Bar graph showing mean ratings of perceived emotional intensity for different emotions after adapting to a small walker. Error bars depict 95% confidence intervals.]

*Figure 11.2.* Mean ratings of perceived emotional intensity for each identified emotion after adapting to a) normal-sized walker or b) small walker. Error bars depict 95% confidence intervals.
11.3.3. Reaction Times for the Perception of the Emotion displayed by the Target Synthetic Walkers

The average perceiver reaction times for identifying each emotion for each perceiver were used as the data scores. Many perceivers failed to correctly identify the emotion in one or more of the cells. A missing value analysis of the data showed that the pattern of missing values was not random. Multiple imputation with five iterations (Ruben, 1996) was used to estimate the scores of these missing values and these estimated scores were included in the analysis. Inferential results were produced by averaging the results of the separate analyses conducted on the five separate data sets. The expectation-maximization algorithm was used to impute the missing variables for each data set.

As was found in the previous experiment, adapting to a neutral emotion did not produce a reaction time aftereffect for identifying sadness (see section 7.2.3.). As such, the perceiver reaction times for identifying sadness after adapting to a neutral walker was compared to adapting to both small and normal-sized emotion displaying walkers. Hence, eight paired sample T-tests were conducted on each data set with an alpha of .05 and a Scheffé correction for multiple comparisons. None of the T-tests reached significance. Adapting to either a small or normal-sized walker displaying an emotion did not produce aftereffects in the time required to identify sadness in subsequently displayed walkers.

It was found in the previous experiment that adapting to a neutral walker produced reaction time aftereffects for identifying happy, anger and fear displaying
walkers (see section 10.2.3.). We therefore cannot use an adapting neutral walker as a statistical comparison to test the adaptation aftereffects of emotion displaying walkers (i.e. happy, anger and fear) in the perceiver identification time of specific emotions in subsequently displayed walkers. As an alternative analysis, we investigated the time perceivers required to identify happiness, anger and fear across all adapting emotions. The consequent interpretation of the statistical results is thus relative to the influence of other adapting emotion walker stimuli instead of neutral stimuli that produce no aftereffects. Consider the potential finding that sadness is identified faster than the rest of the emotions after adapting to a happy walker. This finding could feasibly be interpreted in two ways: 1) The perception of sadness is facilitated after adapting to a happy walker or 2) The perception of happiness, anger and fear is inhibited after adapting to a happy walker. We cannot conclusively interpret the results in favour of one of these two explanations without statistically comparing with an emotion that we know produces no aftereffect (e.g. neutral walker). However, we can infer from the various theories of adaptation aftereffects (discussed in more detail in the next chapter) that the former explanation is more likely than the latter. Nevertheless, the resulting conclusions from these analyses are weaker than those derived from analyses that use a neutral emotion adapting walker as a statistical baseline.

We conducted three separate 5 (adapting emotion) x 2 (walker size) repeated measures ANOVAs for the time perceivers required to identify happiness, anger and fear. Outliers were identified in multiple cells for each of the separate ANOVAs. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of homogeneity of
covariance was not met for the main effect of adapting emotion in the ANOVAs for identified happy and anger and for the interaction adapting emotion by walker size in the ANOVA for identified anger. The Greenhouse-Geisser adjustment to the degrees of freedom was used for all main effects and interactions where the assumption of homogeneity of covariance was not met. All other assumptions for each of the three ANOVAs were deemed satisfactory.

A 5 (adapting emotion) x 2 (walker size) repeated ANOVA was conducted for the perceiver reaction time for the identified emotion of happiness. The main effect of adapting emotion was found to be significant, $F(3.04, 97.14) = 6.32, p < .05$, partial $\eta^2 = .17$, obs. power = .97; as was the interaction adapting emotion by walker size, $F(4, 128) = 12.47, p < .05$, partial $\eta^2 = .28$, obs. power = 1.00. However, the main effect walker size was not significant, $F(1, 32) = .58, p > .05$, partial $\eta^2 = .02$, obs. power = .12. Descriptive statistics are shown in Figure 11.3.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of identification time aftereffects after perceiving a happy synthetic point-light walker. Three of the four remaining relevant post-hoc comparisons reached significance. Happiness was identified significantly slower after adapting to a normal-sized happy walker than a small happy walker, $t(32) = 4.94, p < .05$. Happiness was identified significantly faster after adapting to a normal-sized sad walker than a small sad walker, $t(32) = 3.56, p < .05$. Happiness was identified significantly slower after adapting to a normal-sized happy walker than after a normal-sized sad walker, $t(32) = 5.28, p < .05$. However, there was no
significant difference between the time required for perceivers to identify happiness after adapting to a small happy walker to after adapting to a small sad walker, $t(32) = 2.16$, $p > .05$. The results therefore suggest that happy walkers were identified slower after adapting to a normal-sized happy walker but faster after adapting to a normal-sized sad walker than after adapting to the rest of the studied emotions.

![Graph showing mean perceiver reaction times for identifying different emotions](image)

*Figure 11.3.* Mean perceiver reaction times (ms) for identifying happiness after adapting to each emotion displayed by small and normal-sized walkers. Error bars depict 95% confidence intervals.

A 5 (adapting emotion) x 2 (walker size) repeated ANOVA was conducted for the perceiver reaction time for the identified emotion of anger. The main effect of adapting emotion was found to be significant, $F(3.37, 107.72) = 7.79$, $p < .05$, partial $\eta^2 = .19$, obs. power = .99; as was the interaction adapting emotion by walker size, $F(3.37, 107.83) = 5.47$, $p < .05$, partial $\eta^2 = .15$, obs. power = .95. However,
the main effect walker size was not significant, $F(1, 32) = .96, p > .05$, partial $\eta^2 = .02$, obs. power = .17. Descriptive statistics are shown in Figure 11.4.

![Figure 11.4. Mean perceiver reaction times (ms) for identifying anger after adapting to each emotion displayed by small and normal sized walkers. Error bars depict 95% confidence intervals.](image)

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of identification time aftereffects after perceiving an angry synthetic point-light walker. Three of the seven remaining relevant post-hoc comparisons reached significance. Anger was identified significantly faster after adapting to a normal-sized fearful walker than a small fearful walker, $t(32) = 3.77, p < .05$. Anger was also identified faster after adapting to a normal-sized fearful walker than a normal-sized sad walker, $t(32) = 4.62, p < .05$; and than a normal-sized angry walker, $t(32) = 6.85, p < .05$; but not after adapting to a small angry
walker, \( t(32) = .21, p > .05 \). There was no significant difference in the perceiver reaction times for identifying anger after adapting to a normal-sized angry walker than after adapting to a small angry walker, \( t(32) = 1.10, p > .05 \). There was also no significant difference in the perceiver identification times of anger after adapting an angry walker to after adapting to a happy walker of either the same size, \( t(32) = .61, p > .05 \); or a different size, \( t(32) = 1.58, p > .05 \). The results therefore suggest that angry walkers were identified faster after adapting to a normal-sized fearful walker than after adapting to the rest of the studied emotions.

A 5 (adapting emotion) x 2 (walker size) repeated ANOVA was conducted for the perceiver reaction time for the identified emotion of fear. Both main effects and the interaction were found to be significant: adapting emotion, \( F(4, 128) = 736.95, p < .05 \), partial \( \eta^2 = .95 \), obs. power = 1.00; walker size, \( F(1, 32) = 1272.02, p < .05 \), partial \( \eta^2 = .97 \), obs. power = 1.00; and adapting emotion by walker size, \( F(4, 128) = 355.03, p < .05 \), partial \( \eta^2 = .91 \), obs. power = 1.00. Descriptive statistics are shown in Figure 11.5.

All possible post-hoc comparisons were conducted with a Tukey correction of alpha for multiple comparisons. However, the majority of these comparisons do not inform on the investigation of identification time aftereffects after perceiving a fearful synthetic point-light walker. Four of the five remaining relevant post-hoc comparisons reached significance. Fear was identified significantly faster after adapting to a normal-sized neutral walker than a small neutral walker, \( t(32) = 118.67, p < .05 \); and after adapting to a normal-sized neutral walker than a normal-sized happy walker, \( t(32) = 4.53, p < .05 \). Fear was also identified slower after
adapting to a fearful walker than an angry walker of both the same size, $t(32) = 121.58$, $p < .05$; and of a different size, $t(32) = 18.06$, $p < .05$. However, there was no significant difference between the time required for perceivers to identify fear after adapting to a small neutral walker to after adapting to a small fearful walker, $t(32) = .92$, $p > .05$. The results therefore suggest that fearful walkers were identified faster after adapting to a normal-sized neutral walker but slower after adapting to a small neutral walker than after adapting to the rest of the studied emotions. The results also suggest that fearful walkers were identified slower after adapting to a fearful walker of either size than after adapting to the rest of the studied emotions.

*Figure 11.5. Mean perceiver reaction times (ms) for identifying fear after adapting to each emotion displayed by small and normal-sized walkers. Error bars depict 95% confidence intervals.*
11.4. Discussion

The result of each of the experimental hypotheses is abbreviated in Table 11.2 and will be discussed in the relevant section. The hypotheses that perceivers would identify walkers displaying a specific emotion significantly less after viewing a walker displaying the same emotion but significantly more after viewing a walker displaying the theoretically opposite emotion was only supported for the identification of anger. That is, the identification of anger was inhibited after viewing an angry walker but was facilitated after viewing a fearful walker. The hypothesis that perceivers would take significantly longer to identify the emotion displayed by a walker after viewing a walker displaying the same emotion was only supported for the emotions happy and fear. That is, the time required to identify happiness and fear was inhibited after viewing a happy walker and fearful walker respectively. The hypothesis that perceivers would take significantly less time to identify the emotion displayed by a walker after viewing a walker displaying the theoretically opposite emotion was supported, but only for the emotions happy and anger. That is, the time required to identify happiness and anger was facilitated after viewing a sad and fearful walker respectively. All other hypotheses were not supported.

11.4.1. Adaptation Aftereffects for the Identification of Specific Emotions from Walking Style

The identification of anger was inhibited after adapting to a walker also displaying anger. This result is congruent with the various theoretical explanations of adaptation aftereffects (discussed in more detail in the next chapter); the
Table 11.2

The Result of Each Hypothesis Tested in this Adaptation Aftereffect Experiment

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<th>Result&lt;sup&gt;d,e&lt;/sup&gt;</th>
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<sup>a</sup>ID is an abbreviation for identification. <sup>b</sup>=/</> denotes the direction of the specific hypothesis. <sup>c</sup>Any expression preceding ‘;’ pertains to the specific identified emotion applicable to that hypothesis. <sup>d</sup>✓ denotes a supported hypothesis. <sup>e</sup>x denotes an unsupported hypothesis.

perception of stimuli will be inhibited after adapting to like stimuli (Hsu & Young, 2004; Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992). However, the finding that this was supported for the identification of anger but not the other emotions differs from past research. Hsu and Young (2004) found inhibition aftereffects for the identification of happiness, sadness and fear from
facial expressions. We did not find identification aftereffects for those emotions. However, as will be discussed later in this chapter (see section 11.4.3.), we found identification reaction time aftereffects for all the emotions investigated which is congruent with the theoretical underpinnings of past research (Hsu & Young, 2004).

The inhibition aftereffect for the identification of anger was only found when the adapting walker and the target walker were the same size. Consequently the inhibition effect is low level in nature, namely, the movement of individual dots used to identify anger was inhibited after seeing dots move in a similar manner. Chouchourelou et al. (2006) found that perceivers reported seeing an angry walker within a mask of visual noise even when there was no walker present. The visual noise used was created by using the same movements as the angry walker but randomising the location of each individual dot within the display. The angry walkers in the study by Chouchourelou et al. (2006) were characterised by high velocity movements thus the visual noise also had high velocity motion therefore it appears as if the perceivers in that study were identifying anger by high velocity low level information. The angry walkers in our study were also characterised by high velocity kinematics (see section 8.3.4.). Consequently, it appears that when perceivers adapt to the fast movements of an angry walker then the movements of a subsequently displayed walker do not seem as fast. The identification of anger in the subsequently displayed walker is therefore inhibited.

In contrast, the identification of fear was facilitated after adapting to a walker displaying anger but only when the adapting angry walker and the target fearful walker were of the same size. The facilitation aftereffect for the identification of fear
in walkers is therefore a low level visual phenomenon. Of the three most reported
perceiver identification strategies for fearful synthetic walkers, two of them
described a slower walking pace (see section 9.5.3.4). Additionally, our earlier
conducted kinematic analyses (see section 8.3.4. for more details) show that fearful
walkers displayed short fast steps which will produce a slower walking pace than the
long fast strides of an angry walker (Kirtley, 2006). However, the steps of the fearful
walkers were still relatively fast, despite their short stride length, suggesting that low
level kinematic cues in addition to velocity (e.g. size of movements) are partially
responsible for the facilitated identification of fear following adaption to an angry
walker. Perhaps the visual noise used by Chouchourelou et al. (2006) to mask the
absent angry walkers (created from the same motion as the angry walkers) also had a
different spatio-velocity profile than the masks created from the movements from
point-light walkers displaying alternative emotions (e.g. visual noise used to mask a
sad walker was created from the motion of the sad walker). The perceivers in the
experiment by Chourchourelou et al. (2006) may have therefore perceived the
presence of angry walkers in the mask of visual noise because the dots creating the
mask moved in large fast movements which were distinct to the movement of dots in
the masks used to hide walkers displaying alternative emotions. Nevertheless, our
results are congruent with the various theories of adaptation aftereffects and past
research (Hsu & Young, 2004; Watamaniuk & Heinen, 2007; Wiesenfelder &
Blake, 1992); the perception of a stimulus is facilitated after adapting to the opposite
stimulus including the velocity and shape of motion (Schrater & Simoncelli, 1998).
The facilitated identification of fear after adapting to an angry walker therefore
appears to have its basis in the spatio-velocity profile difference of the individual
dots. The inhibited identification of anger after adapting to an angry walker thus is
also likely to be based in the low level spatio-velocity profile of the dots depicting angry gait.

However, the identification facilitation aftereffect was unidirectional in this experiment. Specifically, the identification of fear was facilitated after adapting to an angry walker but the identification of anger was not facilitated after adapting to a fearful walker. However, as will be discussed later (see section 11.4.3.) an identification reaction time aftereffect was found in the opposite direction. That is, anger was identified faster after adapting to a fearful walker. Therefore when considering the evidence from the perceiver identification rates and reaction times, a bidirectional aftereffect was found for the emotions anger and fear in point-light gait. Congruent with the various theories of adaptation aftereffects and past research (Hsu & Young, 2004; Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992) the perception of a stimulus is facilitated after adapting to the opposite stimulus. Fear is the theoretically opposite emotion to anger according to our circumplex model (see section 2.1.) and the fight-or-flight response (Trivers, 1985). The evidence from this experiment therefore supports the idea that the emotions anger and fear are perceived categorically in opposition to each other.

Nevertheless, the perceived opposite relationship between anger and fear was only found for the low level attributes of the biological motion of walking indicating that the display of anger and fear hold opposite spatio-velocity profiles similar to other low-level aftereffects (Greenlee & Magnussen, 1987; Levinson & Sekuler, 1976; Schrater & Simoncelli, 1998; Watamaniuk & Heinen, 2007). From an ecological perspective (Gibson, 1979/1986), humans initially acquire knowledge
about the world by distinguishing between different environmental phenomena (e.g. light/dark, cold/hot). Our initial knowledge of emotional intent therefore likely developed by perceiving the movement of our primary caregivers and distinguishing between the low-level biological motion attributes (i.e. fast/slow, approach/withdraw) and associating them with the displayed affect. A fast approach to an infant induces a startle reflex and is presumably perceived as dangerous (i.e. angry). The perception of categorically opposite emotions therefore likely developed from opposite spatio-velocity displays of those same emotions. This notion is supported in this experiment where theoretically opposite emotions (i.e. happiness/sadness, anger/fear) were found to have adaptation aftereffect relationships. High level perception of emotion-related biological motion likely built upon these low level distinctions to create a more complex understanding of emotional biological movement (Johnson & Olshausen, 2003).

However, the perceivable biological movements that are used to categorically distinguish between different displayed emotions will vary between individuals. A fit athletic person is likely going to display faster vitiating movements in general due to their increased muscular strength and flexibility. In contrast, an obese person is likely going to display shorter, slower movements in general due to the constraints put upon their muscles and joints by excess body fat (Michalak et al. 2009). If the perceived emotion categorical boundaries from biological movement were relatively stable; then it would be more difficult to perceive the slow sad movements displayed by the athletic individual and the fast angry movements displayed by the obese individual. The consequent errors in the individual’s emotion
perception system could potentially lead to adverse social interactions (e.g. perceiving an obese angry person as sad).

We argue that adaptation aftereffects serve a social function by recalibrating the perceived categorical boundaries for each emotion to the specific movements of the individual displaying the emotion. For example, adapting to the fast movements of an individual makes the subsequent perception of fast movements more difficult but slow movements easier to perceive. The perception of fast and slow movements is thus perceived relative to the individual displaying the movements. The emotion specific information associated with particular movements is therefore also perceived relative to the individual. Consequently, the relatively distinct emotion categorical boundaries are maintained and recalibrated to each specific individual thus facilitating further social interaction based on emotion perception. Our finding that a 12 second adaptation time to a specific emotion display was sufficient to influence the perception of subsequently displayed emotions showed that the recalibration of the emotion perception system is relatively fast thus suitable for effective social functioning in new interactions.

11.4.2. Adaptation Aftereffects for the Perceived Emotional Intensity of Walkers Displaying Specific Emotions

In this experiment we found no inhibited or facilitated adaptation aftereffect for the perceived emotional intensity of walkers displaying specific emotions.

11.4.3. Adaptation Aftereffects for the Perceiver Reaction Time for Identifying Specific Emotions in Walkers
Happy walkers were identified slower after adapting to a happy walker and faster after adapting to a sad walker. Under the assumption that easily identified emotions will be identified relatively fast (supported by experiments 1 and 2); it thus appears that the perception of happiness is inhibited after adapting to a happy walker and facilitated after adapting to a sad walker. These results are congruent with current adaptation aftereffect theory and with past research (Hsu & Young, 2004; Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992). Whilst Hsu and Young (2004) found like results with the identification of happiness from facial expressions, they found the aftereffect relationship between happiness and sadness to be bidirectional which clearly diverges from our results.

The reason for the incongruence between our results and Hsu and Young’s (2004) may lie in our finding that both the facilitated and inhibited aftereffect for the identification of a happy walker was only evident when the adapting walker and the target walker were the same size. These happy walker related aftereffects therefore appear to be low level visual phenomenon, caused by the movements of individual dots. Apparently, the studied emotions can be perceived solely from low-level information but may possibly be enhanced by the inclusion of high-level information (Atkinson, in press). Our previously conducted kinematic analyses (see section 8.3.4.) showed that happy walkers displayed more velocity and larger movements than the walkers displaying sadness. The dots depicting a happy walker therefore appeared to move faster and further after adapting to the short slow moving dots of a sad walker. Consequently, happiness was identified faster after adapting to a sad walker. In contrast the short slow moving dots of a sad walker may have appeared to
move less far and slower after adapting to the large fast moving dots of a happy walker.

Nevertheless, given that the velocity and size of low level motion contributed to the aftereffect relationship between happiness and sadness found in our study; our use of perceiver identification time as a dependent variable may have caused our unidirectional finding. Happiness was identified more quickly after adapting to a sad walker but sadness was not identified more quickly after adapting to a happy walker. Walking is a cyclical biological motion thus the low level motion of each dot in the point-light display is also cyclical. Speculatively, perceivers likely waited to see the entire cycle of motion before making their emotion categorisation. A slower cycle of motion will therefore cause a slower perceiver categorisation. The consequent slower categorisation times for sadness may thus have counteracted any legitimate facilitated perception for the time required to identify sadness after adapting to a happy walker.

Likewise, anger was identified faster after adapting to a fearful walker but only when the walker was the same size indicating a low level phenomenon. The large fast movements of an angry walker may have appeared larger and faster after adapting to the relatively small slow motions of a fearful walker (see section 8.3.4.). Consequently the speed at which anger was identified was facilitated after adapting to a fearful walker. In contrast the perceptually slower movements of a fearful walker after adapting to the fast movements of an angry walker may have induced the perceiver to take more time before identifying the walker as fearful. Consequently, the facilitated perception for the identification time of a fearful
walker after adapting to an angry walker may have been counteracted. However, as previously discussed (see section 11.4.1.) fear was identified better after adapting to an angry walker thus supporting the theoretically opposite relationship between anger and fear.

The velocity and size of movements obviously provides an incomplete picture of the display of emotions through low level motion. Both happiness and anger were identified by larger faster motions relative to sadness and fear but only the theoretically opposite emotions (i.e. happiness/sadness, anger/fear) produced aftereffect relationships. There must therefore be some low level difference in addition to the velocity and size of movement that underlies the adaptation aftereffects found in this experiment. Specifically, there must be some difference in the low level properties of the large fast motions of happy and angry walkers. Similarly, there must be some low level difference between the small slow motions of sad and fearful walker. Otherwise, adapting to a fast walker (e.g. angry) should produce facilitation aftereffects in the perception of emotions displayed by both slow walkers (i.e. sad and fearful) and vice-versa. To obtain a more complete understanding of the display of the different emotions through low level motion, an analysis of the shape of the low level movements (i.e. spatio-velocity profile) is needed. Such an analysis is beyond the scope of this thesis/study; nevertheless, we recommend that future research be directed towards the investigation of the low level spatio-velocity profiles of different emotional displays.

Fear was identified slower after adapting to a fearful walker of either size or a small neutral walker. The inhibited identification time of fear after adapting to a
fearful walker is congruent with current adaptation aftereffect theory and past research (Hsu & Young, 2004; Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992). However, the additional inhibited perception of fear after adapting to a small neutral walker is surprising especially since adapting to a normal sized neutral walker facilitated the perception of fear. This finding indicates that the gait movements of a neutral walker and a fearful walker are distinct when the adapting walker and the target walker are the same size but similar when they are displayed in different sizes. Considering that the synthetic walker displaying fear was identified much less than the other synthetic walkers and that neutral was a default option for perceivers when they could not perceive any emotion (see sections 7.4.2.2. & 9.5.1.), it stands to reason that the fearful walker and the neutral walker have some similar gait kinematics. Nevertheless, perceivers are able to distinguish fearful walkers from neutral walkers above chance indicating that kinematic display of fear and neutral is distinct despite some similarities. The low level kinematic differences between the adapting neutral walker and the target fearful walker are more easily contrasted when both walkers are the same size. However, when the size of the target walker is reduced, the movement of the dots depicting both fearful and neutral walkers become smaller and thus less perceptually distinct. The perception of fear is therefore facilitated when the adapting neutral walker is the same size but inhibited when the adapting neutral walker is smaller than the target fearful walker.

11.5. Conclusion

We have found evidence of adaptation aftereffects for the identification and identification times of specific emotions in walking style. For the most part, these aftereffects appear to be low level phenomenon and thus caused by the adaptation to
spatiotemporal characteristics of the movements of the individual dots, not by the adaptation to a specific emotion. The evidenced aftereffect relationship of anger with fear supports the notion that both emotions are expressed through opposite gait movements which are perceived categorically congruent with the emotions theoretically opposite relationship. With knowledge of which emotions produce adaptation aftereffects in the perception of other emotions we can now directly compare two opposing theories on adaptation aftereffects. In the next experiment, we will compare the neural fatigue theory (Georgeson, 2004; Hsu & Young, 2004) against the adaptation theory (Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992) by altering the length of time between the adapting walker and the target walker.
Chapter 12

Experiment 5: Neural Fatigue Theory vs. Adaptation Theory

The neural fatigue theory was tested against the adaptation theory of adaptation aftereffects. The neural fatigue theory argues that when an individual perceives a stimulus (e.g. happy walker) the neural population that is activated to perceive that stimulus become fatigued thus making it more difficult to perceive subsequent displays of the same stimulus (i.e. happy walker). Consequently, the perception of an opposite stimulus (e.g. sad walker) is facilitated. In contrast, the adaptation theory argues that after adaptation to a given stimuli (e.g. happy walker), the criterion used by a perceiver to determine what is a good example for that given stimuli (e.g. happy walker) is shifted in favour of the opposing stimuli (e.g. sad walker). Adaptation theory is explained neurologically through the changing of the synaptic weights of the neuronal network used to perceive a particular stimulus (Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992). The fundamental, and testable, difference between the two theories is whether an aftereffect will be stored and thus endure through a period of non-stimulation. The neural fatigue theory argues that the adaptation aftereffects will only persist for the duration required for the neural population to recover from their previous over-stimulation. In contrast, the adaptation theory argues that an aftereffect will be stored through a period of non-stimulation until the synaptic weighting of the neuronal network used to perceive that particular stimulus is modified through perception of a different stimulus.

Studies seeking to test the neural fatigue theory against the adaptation theory have interspersed blank screens (i.e. non-stimulation) of different temporal durations
between the adapting stimulus and the target test stimulus (i.e. ISD, Culham et al., 1999; Hsu & Young, 2004; Watamaniuk & Heinen, 2007). However, the lack of definitive neuron recovery time has caused confusion in the literature. For example, Hsu and Young (2004) argued that neural fatigue best explains the adaptation aftereffects found in the perception of specific emotions from facial perception despite the effect enduring a period of non-stimulation of 1s. Though Watamaniuk and Heinen (2007) argued that neural fatigue could not possibly explain motion aftereffects because they endured after a period of non-stimulation lasting 1s. However, Culham et al. (1999) argues that since motion aftereffects last approximately 10s that a non-stimulation period of 10s is sufficient time for the fatigued neural populations to recover thus any aftereffects that persist after the period of non-stimulation can not be explained by the neural fatigue theory. Culham et al.’s (1999) reasoning is challenged by Hoffmann, Dorn and Bach’s (1999) finding from electrophysiological and psychophysical data that after an adaptation period of 7.7s a period of 16.7s is needed for the neurons to recover from the perceptual motion aftereffect. The time required for neural populations to recover from over-stimulation is clearly ambiguous in the literature.

In order to validly test the two competing theories against each other it is imperative that the period of non-stimulation be of an adequately long duration to ensure that the neural populations activated to perceive specific emotions in walking style can recover from their over-stimulation. Of all the papers reviewed, Hoffmann et al. (1999) identified the most conservative time duration that neuronal populations required to recover from neural fatigue (i.e. 16.7s). Therefore in this experiment, an
even more conservative time duration (i.e. 20s) was used as the ISD to ensure that the neural populations had enough time to fully recover from fatigue.

The neural fatigue theory and the adaptation theory both can explain the existence of adaptation aftereffects in the visual perception of specific emotions from walking style. The aim of this experiment is to directly test these two competing theories against each other and thus determine which neural mechanisms can be assumed to be the cause of any adaptation aftereffects found in the previous experiment. If the neural fatigue theory is supported then it is predicted that the adaptation aftereffects that were found when there was a 1s ISD (i.e. previous experiment 4b), will disappear when the ISD is increased to 20s. In contrast, if the adaptation theory is supported then it is predicted that adaptation aftereffects will be found at both ISD’s (i.e. 1s and 20s).

12.1. Method

12.1.1. Participants

The sample of perceivers comprised 5 male and 19 female (N = 24) first year psychology students (from the University of Western Sydney) in return for course credit. The sample had a mean age of 21.42 years (SD = 7.86). All perceivers had normal or corrected to normal vision. Informed consent was obtained from each perceiver (Appendix N).

12.1.2. Materials

The materials used in this experiment (Appendix O) were the same as the materials used in experiment 4b but with some modifications. A blank screen was
shown for 20s between the adapting emotion and the target emotion (i.e. ISD). To avoid perceiver confusion, a text box (i.e. “Next Stimulus Pair”) was interjected between each pair of walkers. Additionally, due to time limitations caused by the longer ISD, only pairs of emotional synthetic walkers that were found to have significant adaptation aftereffects in experiment 4b were included in this experiment.

12.1.3. Procedure

The procedure was the same as that used in experiments 4a and 4b.

12.2. Results

We are seeking to confirm the results from the previous experiment but with a longer ISD. As such, we conducted the same paired sample analyses that were found to be significant in the previous experiment.

12.2.1. The Identification of the Emotion Displayed by the Target Synthetic Walker

Each perceiver’s raw frequency scores for each cell of the design were converted to Hu scores to control for repeated measures stimulus presentation, observer bias, and the overestimation of perceiver performance and then the scores were arcsine transformed for the purpose of these analyses (Wagner, 1993). Only correct perceiver identifications were statistically analysed. Mean Hu scores for each identified emotion after each adapting stimulus are shown in Figure 12.1. Outliers were detected in each cell used in the comparisons. The outliers were reduced to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The assumption of normality was violated in each cell. Therefore the non-parametric Wilcoxon Signed-Rank test was performed comparing the Hu scores for
the identified emotions of anger and fear after adapting to a neutral walker and after adapting to an angry walker. By doing so we are repeating the same two comparisons that were found to be significant in the previous experiment. A Bonferroni corrected alpha of 0.025 was used for each comparison.

There was no significant difference in the Hu scores for identifying anger after adapting to an angry walker compared to after adapting to a neutral walker, \( z(N=24) = .49, p = .626 \). Nor was there a significant difference in the Hu scores for identifying fear after adapting to an angry walker compared to after adapting to a neutral walker, \( z(N=24) = .54, p = .593 \).

\[ \text{Figure 12.1.} \text{ Mean perceiver Hu scores (proportions) for the identification of anger and fear after adapting to either a neutral walker or an angry walker.} \]
12.2.2. The Perceiver Reaction Time for the Identification of the Emotion Displayed by the Target Synthetic Walker

The average perceiver reaction times for identifying each emotion for each perceiver were used as the data scores. Many perceivers failed to correctly identify the emotion in one or more of the cells. A missing value analysis of the data showed that the pattern of missing values was not random. Multiple imputation with five iterations (Ruben, 1996) was used to estimate the scores of these missing values and these estimated scores were included in the analysis. Inferential results were produced by averaging the results of the separate analyses conducted on the five separate data sets. The expectation-maximization algorithm was used to impute the missing variables for each data set.

We conducted the same comparisons that were found to be significant in the previous experiment. Hence, 10 dependent sample t-tests were conducted on each data set with an alpha of .05 and a Scheffe correction for multiple comparisons. Outliers were identified in several of the cells used in the dependent sample t-tests. The outliers were reduced/increased to within one unit of the next most extreme score in the cell (Tabachnick & Fidell, 2001). The rest of the assumptions of the dependent sample t-tests were deemed satisfactory. None of the t-tests reached significance.

12.3. Discussion

The adaptation aftereffects that were found in the previous experiment with an ISD of 1s disappeared in this experiment when the ISD was extended to 20s. These findings therefore support the neural fatigue theory (Georgeson, 2004; Hsu &
Young, 2004) of adaptation aftereffects. The contrasted adaptation theory (Culham et al. 1999; Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992) was not supported. The neural fatigue theory thus appears to be the best explanation for the influence of adaptation aftereffects on the perception of emotions from walking style. That is, the neural populations activated during the perception of an emotion become fatigued thus inhibiting the perception of the same emotion displayed through gait. Consequently, the perception of the opposite emotion is facilitated.

Our evidential support for the neural fatigue theory is congruent with previous research on the influence of aftereffects on the perception of emotions (Hsu & Young, 2004). We can therefore interpret our findings from the previous experiment (i.e. experiment 4b) in terms of the neural fatigue theory. That is, the neuron populations used to perceive the low level properties of emotion displaying walkers (e.g. spatio-velocity profile of individual dots) become fatigued after being utilised thus adaptation aftereffects will occur until the neural populations recover from their stimulation. The facilitation effects found in the previous experiment suggests that the neural populations keyed towards perceiving specific emotions through low level biological motion are not completely isolated but instead organised in a way where there is partial communication with the neural populations for perceiving the low level properties of the theoretically opposite emotion (Hsu & Young, 2004). The vast majority of studies investigating adaptation aftereffects have investigated low level bipolar variables where there is a distinct opposite (e.g. angling of a line left or right, Greenlee & Magnussen, 1987; direction and velocity of motion, Levinson & Sekuler, 1976; Schrater & Simoncelli, 1998; moving eyes up and down, Watamaniuk & Heinen, 2007). Our findings thus are more relevant to previous
research on low level adaptation aftereffects than to the high level aftereffect literature on emotion perception (e.g. Hsu & Young, 2004). Nevertheless, low level motion is sufficient for identifying happiness, sadness, anger and fear from point-light displays. Future studies could use fMRI and kinematic analysis to explore the relationship between the neural populations utilised to perceive low level motion and those used for emotion perception.

Our findings are incongruent with previous research showing that aftereffects can be stored after a period of non-stimulation (Culham, 1999; Watamaniuk & Heinen, 2007). The adaptation explanation of aftereffects posits that aftereffects will persist until the synaptic weighting of the neuronal network used to perceive a particular stimulus is modified through perception of a different stimulus. Therefore according to the adaptation theory the aftereffect will retain full strength through a period of non-stimulation. In contrast, the neural fatigue explanation of aftereffects not only argues that the utilised neural populations will recover through a period of non-stimulation but also that longer adapting times require longer recovery time before the aftereffect disappears (Hoffmann et al. 1999; Troje et al. 2006). However, the literature is ambiguous regarding the required recovery time for utilised neuronal populations after adapting to stimuli of varying durations. The adapting stimuli used by Culham (1999) had duration of 36s thus creating a stronger aftereffect therefore requiring a sufficiently long enough time for the utilised neuronal populations to recover. Consequently, an aftereffect caused by neural fatigue might have still been present after the averaged ISD among perceivers (i.e. 16s). Similarly, Watamaniuk and Heinen (2007) used adapting stimuli of 60s duration with only 1s ISD. In both studies, the neural fatigue theory was rejected based on an unsubstantiated
assumption that the ISD used in their experiments was sufficient to allow the utilised neural populations to recover from adaptation to their initial stimuli (Culham, 1999; Watamaniuk & Heinen, 2007). The short ISDs relative to the long adaption times suggests that the neural populations utilised might not have had sufficient time to recover (Culham, 1999; Watamaniuk & Heinen, 2007).

The literature is ambiguous on how much time is required for the utilised neuronal populations to recover. Nevertheless, our adaptation time (i.e. 12s) was shorter than the majority of the reviewed studies (Culham, 1999; Hoffman et al. 1999; Hsu & Young, 2004; Watamaniuk & Heinen, 2007) and our ISD (i.e. 20s) was longer than the longest ISD used in the literature (i.e. 16.7s, Hoffmann et al. 1999). Since longer adapting times require longer recovery times (Hoffman et al. 1999; Troje, 2006), we can be reasonably certain that our storage time of 20s was sufficient to allow the neurons to recover from a 12s adaptation to emotion displaying point-light walker stimuli. Our evidence therefore clearly supports the neural fatigue explanation for adaptation aftereffects.
Chapter 13

General Discussion

Throughout this thesis, various aspects of emotion perception and expression have been investigated through the biological motion of walking. The major findings will now be summarized and their implications discussed in light of the relevant literature.

13.1. Perception of Specific Emotions from the Kinematics of Gait

A Vicon motion capture system (version 1.1., Oxford Metrics Limited) and a video camera to record 17 female and 19 male actors displaying the emotions happiness, sadness, anger, fear and a neutral comparison through their walking style. Full-light, point-light and synthetic point-light walker stimuli were constructed and shown to perceivers in the experiments conducted in this thesis. The first three experiments investigated the perception of four basic emotions (i.e. happiness, sadness, anger, fear and a neutral base comparison) through walking style as displayed by full-light, point-light and synthetic walkers respectively. The amount of perceivable walker information was systematically reduced with each successive experiment consequently reducing the identification rates for each emotion. The full-light walker stimuli displayed walker information in an ecologically valid format. However, a range of influential factors were also perceivable (e.g. body composition, non-gait expressions of emotion such as hand clenching) which enhanced the perception of the majority of the emotions. Displaying point-light walkers as stimuli reduced the perceivable walker information to the kinematic properties of emotional gait with the exception of some structural information which
was still perceivable (Cutting et al. 1978). Furthermore, each point-light walker expressed the emotions through their own idiosyncratic walking style. The synthetic walker stimuli further reduced the stimulus information to the average gait kinematics displayed by an averaged walker body thereby controlling for any structural differences between the walkers. As the synthetic walkers were compiled from the kinematic gait features common to all walkers displaying a particular emotion, they removed idiosyncratic walking styles effectively isolating the specific kinematics associated with the emotions of interest.

There is an inherent relationship between the expression and consequent perception of the emotions displayed through gait. An emotion can only be perceived if is successfully displayed through biological movement. We therefore tested both the expression and perception of specific emotions through walking gait movements. Firstly, kinematic analyses on the recorded 3D motion data were carried out, testing the utility of the perceiver’s reported emotion identification strategies for distinguishing between different emotions displayed through gait. Walking pace was found to be a significant indicator of the displayed emotion, specifically: a long steady stride indicates happiness, a short slow stride indicates sadness, a long fast stride indicates anger and a short fast stride indicates fear in the walker. Also, the arm movements of the walkers successfully distinguished between the displayed emotion, though less so than walking pace. Angry and happy walkers displayed more arm movement than sad or fearful walkers, which is a by-product of a faster walking pace (Kirtley, 2006). However, sad and fearful walkers displayed less arm movement in different ways. Sad walkers moved their entire arms relatively little whilst fearful walkers primarily moved their lower arms throughout their walk.
Secondly, the perception of happiness, sadness, anger, fear and neutral emotions displayed through walking gait was investigated. The research reported in this thesis has improved on much of the previous research on the perception and expression of emotions through walking gait. Each of the studied emotions was identified above chance in each of the three display formats which provides the needed referential justification for some past studies (Heberlein et al, 2004) that emotions can indeed be perceived from walking style. The few studies to actually test whether emotions can be perceived from gait have been constrained by methodological limitations (e.g. unreliable priming methods, Montepare et al. 1987; Westermann et al. 1996; and untested emotion stereotypic displays of emotions by actors, Chouchourelou et al. 2006; Heberlein et al. 2004). The present use of both male and female walkers as stimuli improves on the research conducted by Montepare et al. (1987) who showed perceivers a predominance of female walker stimuli. Males and females display different gait kinematics (Troje, 2002) which in the present study were found to influence the perception of emotions in walkers. Additionally, our kinematic analyses were driven by perceptual experiment data indicating that some of the kinematic displays of the basic emotions are perceivable to observers which remained untested by Michalak et al. (2009). Furthermore, Michalak et al. (2009) reported that the emotion specific gait kinematics was constrained by the structural differences of the individual walkers (i.e. weight) which would be perceivable to observers (Jokisch & Troje, 2003; Westhoff, 2005). Our creation and subsequent testing of synthetic walker stimuli controlled for the influence of structural differences and idiosyncratic walking styles of the different walkers (Wallbott & Scherer, 1986). Additionally, synthetic walker stimuli in the
present study were constructed from locomotive walkers which are more
ecologically valid that the synthetic treadmill walkers Troje and colleagues show on
their website (http://www.biomotionlab.ca/Demos/BMLwalker.html). Furthermore,
our synthetic walker construction established that locomotive walkers exhibit greater
variability in the gait movements than Troje’s
(http://www.biomotionlab.ca/Demos/BMLwalker.html) treadmill walkers thereby
confirming that treadmill gait is different from locomotive gait (Westhoff, 2005;
White et al. 1998) which likely influences the communication of specific emotions
through gait kinematics. Moreover, our inclusion of fearful walkers extends the
current literature to include fear in the set of emotions that can be perceived and
displayed through walking style.

The relative identification rates for the studied emotions varied between the
different display formats (see Table 13.1). Sadness and fear was identified best in
full-light walkers, followed by happiness, and anger was identified the least well out
of the studied emotions. When the walker information was reduced to point-light
display, sad and fearful walkers were identified equivalently with happy walkers.
Apparently the perception of sadness and fear benefits more so than happiness and
anger by relating structural information not perceivable in point-light display to
specific gait kinematics. When the point-light walker stimuli were further reduced to
the kinematically based synthetic walkers, identification rates for anger remained
relatively constant, while the identification rates for the other studied emotions were
further reduced. This suggests that anger is displayed more so through gait
kinematics than the other emotions. Whilst all of the emotions could be identified
above chance solely through the kinematics of gait, it appears that the perception of
sadness and fear and to a lesser extent happiness is further enhanced by additional
movements that are not specific to gait kinematics (e.g. head turning, lethargic
posture). With very few exceptions (Atkinson, in press; Atkinson et al. 2004), the
influence of display format on the perception of emotions has not previously been
investigated. Furthermore, our research is the first to investigate the influence of
display format on the perception of emotions from the relatively restricted
movements of walking gait.

Table 13.1

*The Identification Rates for Each Emotion Displayed by Walkers Split by Display
Format.*

<table>
<thead>
<tr>
<th>Displayed Emotion Category</th>
<th>Happy</th>
<th>Sad</th>
<th>Anger</th>
<th>Fear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full light Walker</td>
<td>.406</td>
<td>.533</td>
<td>.325</td>
<td>.567</td>
</tr>
<tr>
<td>Point light Walker</td>
<td>.306</td>
<td>.279</td>
<td>.248</td>
<td>.273</td>
</tr>
<tr>
<td>Synthetic Walker</td>
<td>.212</td>
<td>.224</td>
<td>.264</td>
<td>.097</td>
</tr>
</tbody>
</table>

*Note.* The identification rates are represented as Hμ scores which can be interpreted as the percentage that each emotion displaying walker is correctly identified given that the stimulus is correctly displayed.

In each of the first three experiments in the present study the gender of the walker influenced the perception of the emotion ascribed to walkers. Each of the emotions (except fear) was identified better in female full-light walkers than male full-light walkers. However, this advantage in the perception of happiness in female walkers was nullified in point-light walkers. However, fear was perceived better in female synthetic walkers. The variable of walker gender is a complex one and difficult to investigate in the limited number of experiments of the present research.
For example, we could not unequivocally conclude whether the differences in our perceptual experimental results were due to perceiver bias caused by associating specific emotions with gender role stereotypes or whether female walkers were merely better displayers of emotions through gait or due to another confounded variable (e.g. structural dimensions of walker). However, the gender ambiguous synthetic walker stimuli used here typically mediated any differences in the perception based results between male and female synthetic walker stimuli indicating that our gender ambiguous synthetic walker stimuli did control for the influence of gender on the perception of emotions in gait. Nevertheless, we found that happiness, sadness, anger and fear could be perceived from walking gait despite the influence of the walker’s gender. Consequently, the findings of Montepare et al. (1987), who only showed perceivers female walkers, can now also be generalised to male walkers.

We systematically tested the alarm hypothesis (Walk and Homan, 1984) throughout the first three experiments with full-light, point-light and synthetic walkers. The alarm hypothesis (Walk & Homan, 1984) is derived from ecological theory (Gibson, 1979/1986; McArthur & Baron, 1983) and argues that individuals perceive anger, followed by fear, more accurately and easily due to their relative importance to the individual’s immediate survival. None of our hypotheses derived from the alarm hypothesis (Walk & Homan, 1984) were supported. Walkers displaying anger, followed by fear, were not identified better, quicker and or at a lower level of displayed intensity than the other emotions. The alarm hypothesis (Walk & Homan, 1984) was therefore rejected for the perception of basic emotions displayed through walking gait.
13.2. *The Influence of Adaptation Aftereffects on the Perception of Specific Emotions from the Kinematics of Gait*

A second set of experiments utilised improved synthetic walker stimuli to investigate the influence of adaptation aftereffects on the perception of emotions from walking style. Adaptation aftereffects are well known in visual perception research ranging from low-level phenomena (e.g. velocity of motion, Schrater & Simoncelli, 1998) to high-level biological motion (e.g. face shape, Webster & Maclin, 1999; facial expressions of emotion, Hsu & Young, 2004; walker gender, Jordan et al., 2006; Troje et al., 2006). In the present study adaptation aftereffects did influence the perception of emotions in walkers. After adapting to an angry walker, the identification of anger was inhibited but the identification of fear was facilitated. The opposite relationship was found in our reaction time data, specifically: after adapting to a fearful walker, fear was identified slower but anger was identified faster than the rest of the studied emotions. The perception of fear and anger appear to be intimately linked. The various theories of adaptation aftereffects agree that the perception of a stimulus is inhibited after adapting to a similar stimulus and facilitated after adapting to an opposite stimulus (Hsu & Young, 2004; Watamaniuk & Heinen, 2007; Wiesenfelder & Blake, 1992). The aftereffect relationship between anger and fear was found to be based on the low-level properties of the walker stimuli thus there is some low-level aspect of the display of anger and fear in walkers that is oppositional in nature. Similarly, happiness and sadness appear to hold a similar low-level relationship. Happy walkers were identified slower after adapting to a happy walker but faster after adapting to a sad walker than after adapting to the rest of the studied emotions. There is evidence that
anger is perceived through high velocity movement (Chouchourelou et al. 2006) which is congruent with the kinematic analyses we conducted on our point-light walker stimuli. Happiness appeared to be displayed through low level motion similar to the display of anger but not quite as fast or large. Furthermore, our kinematic analyses indicated that displays of sadness were characterised by small low velocity movements and fear by short high velocity movements. However, our kinematic analyses were inadequate to explain how the movements used to display each emotion in the aftereffect relationship (i.e. happiness/sadness, anger/fear) were opposite in motion.

Our evidence clearly supports the neural fatigue theory over the adaptation theory of adaptation aftereffects therefore indicating that there are specific neural populations attuned to the perception of the low-level attributes of emotional display in walkers. Furthermore, these specific neural populations appear to share an oppositional relationship. This is not surprising. From an ecological perspective (Gibson, 1979/1986), humans initially acquire knowledge about the world by distinguishing between different environmental phenomena (e.g. light/dark, cold/hot, slow/fast). Similarly, our perception of emotional intent likely developed by distinguishing between the simple but opposite bodily movements used to display those same emotions (previously discussed in more detail in section 11.4.1.). Specific neural populations thus attuned to the perception of these low level motions were neurologically associated with those used for emotion perception. High level perception of emotion-related biological motion likely build upon these initially developed neural populations to create a more complex understanding of emotional biological movement (Johnson & Olshausen, 2003).
13.3. Future Research Directions

It has been shown throughout the present research that the emotions happiness, sadness, anger and fear can all be perceived solely through the kinematics of gait. However, Jokisch et al. (2006) found that viewing perspective influenced the identification of other individuals depicted as point-light walkers. Emotion perception from gait kinematics could feasibly be not invariant to viewing perspective. Some of the gait movements used to display the emotions of interest (e.g. arm swing and stride length) may be better perceived from an alternative viewing perspective (e.g. profile perspective) than the frontal perspective where the depth information of point-light displays is difficult to pick up. Future research may therefore investigate how the perception of each emotion may differ in relation to the viewer’s perspective of the walker (i.e. frontal vs. profile vs. 45° hybrid perspective).

Additionally, as we have identified a range of emotion-specific gait movements associated with the basic emotions happiness, sadness, anger and fear, future studies no longer need to use untested emotional gait movements in their investigations into the perception of emotions from gait. The neural link between emotion perception and emotion expression (Adolphs, 2001; Blakemore & Decety, 2001) suggests that specific emotions may be successfully induced by moving in a way congruent to the bodily display of that emotion. Thus based on the findings of this study, future research could investigate this theoretically bi-directional relationship between emotion and bodily movement by instructing individuals to
walk with the identified emotion-specific gait movements and measuring their emotional states.

We also found that the walker’s gender influenced the perception of emotions displayed through gait which affords future research opportunities investigating the complex relationship between a walker’s gender and emotion perception (as previously discussed in section 13.1.). Walker gender could be investigated from many theoretical perspectives (e.g. gender role stereotyping, Grossman & Wood, 1993; gender-specific bodily expression, Troje 2002). Whilst our results have been argued to be best explained by the greater expressive skill of female actors compared to male actors (Grossman & Wood, 1993), it is still feasible to consider that other gender-related issues likely influenced the perception of each emotion (e.g. implicit perceptive bias towards certain emotions for a particular gender, structural size of walker). Future research could investigate the influence of gender-related variables on emotion perception. For example, a perceiver’s implicit bias for perceiving a particular emotion when the walker is a particular gender (e.g. angry male) could be investigated with a biological motion version of the Implicit Attitude Test (IAT). Gender ambiguous emotion specific walkers may be paired with the labelled choice of male or female. Emotions that hold a perceptual bias towards a particular gender will be identified faster when paired than non-biased pairings. Additionally, it is feasible to consider that the intra-gender and inter-gender relations of perceiver and walker likely influenced the perception of specific emotions. The conducted experiments could therefore be replicated to investigate intra-gender and inter-gender emotion perception in gait by matching a particular gender of perceivers with a particular gender of walkers (i.e. male perceiver/female walker, female
perceiver/male walker, male perceiver/male walker, & female perceiver/female walker).

Furthermore, theoretically opposite emotions were found to exhibit low level adaptation aftereffect relationships (i.e. happiness/sadness, anger/fear). Our kinematic analyses were inadequate to explain how the low level movements displaying each emotion in the aftereffect relationship were opposite in their spatio-velocity profile (see section 13.2.). The exact nature of these low-level aftereffects could be investigated in further research by using the recorded motion data of the emotional walkers to create a mask of visual noise with no walker present. Assuming that perceivers can still identify the emotion displayed in the visual noise, researchers may then manipulate various low-level attributes (e.g. rotate the display of the stimuli 90° to investigate the inversion aftereffect; differentially modify the speed of the stimuli to investigate motion aftereffects). Once these low-level properties of emotion display have been identified, they can be correlated in further research with the previously established neural pathways for identifying emotions in point-light walkers (right somatosensory cortices, Heberlein et al. 2004; superior temporal sulcus, Chouchourelou et al. 2006). From such an approach, it would be possible to obtain a clearer understanding of how emotion is communicated to perceivers through simple low-level motion.

13.4. Potential Applications of this Research

This research has numerous applications for real world benefits. The first and most obvious is the entertainment industry (i.e. film and computer games) who can now use the empirically tested emotion-specific gait motion data to create artificial
characters that validly display specific emotions in a more realistic fashion. Similarly, with the relatively recent development of online virtual communities, the use of avatars that can validly display the users desired emotional expression can facilitate online socialization. Furthermore, actors and dancers can now be instructed on how to accurately display specific emotions (i.e. happy, sad, anger and fear) through the simple act of walking. Actor/dancers no longer need to rely on stereotypic emotional gait movements and can factor out any perceptually confusing information that may be present in their current emotional gait displays.

Additionally, emotion specific gait kinematics can be programmed into various computer systems to accurately identify the expressed emotion of an oncoming user. Such computerized emotion identification systems could be used to improve the personable interactive capabilities of artificial agents for public information services and also to automatically identify potential security threats (e.g. angry or fearful walks) in high security thoroughfares (e.g. airports) who can then be investigated further by human security personnel. Furthermore, current biometric security systems can be improved to accurately identify individuals whilst adjusting for gait variations due to different emotional states.

On a more human level, clinical psychologists can use knowledge of emotion-specific gait styles to conduct a quick and inexpensive psychological assessment of their clients as they walk into the office. This same knowledge may be further utilized by the broader community to improve current anti-victimization programs. Individuals who have been repeatedly victimized may be taught how to walk in a way that may discourage potential attackers (e.g. an angry gait).
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Participant Information Sheet

“The Perception of Emotion from Walking Style”

Ethics Approval: HREC 06/145

Rationale for the study
This research is designed to increase understanding around the perception of affect in walking style.

What you will be asked to do
Your role is to walk across a room several times whilst your movement will be recorded. Your movement will be recorded using infra-red markers that will be placed on various joints on your body. Because of the recording equipment used you will be required to wear spandex tights/bike pants and a singlet/crop top, which you are asked to bring with you on the day. Each time you walk across the room you will be asked to display one of several emotions (i.e. happy, sad, anger, fear, or neutral) at a different level of intensity (i.e. low, moderate, or high). All five emotions at each of the three levels of intensity will be recorded.

Participation is voluntary
Participation in this study is voluntary and you may withdraw at anytime without penalty/adverse consequences or reason. All information gathered will be strictly confidential and no published information will be used to identify you. Copies of the research data will be stored under password on a computer, and hard copies stored in a locked filing cabinet in the laboratory of the primary researcher.

The findings of this research will be submitted for a PhD thesis assessment and may lead to professional publication.

Who is running the research
This research is being conducted by a PhD student of the name Shaun Halovic at the University of Western Sydney. Any queries about the research should be directed to Shaun Halovic (ph: 0416036183).

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 4570 1136). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Participant Consent Form

“The Perception of Emotion from Walking Style”

Ethics Approval: HREC 06/145

I,_________________________________________, have read and understood the information in the plain language statement, and any questions I have asked have been answered to my satisfaction. I understand that my participation is voluntary and understand that I can withdraw at any time. I have been given a copy of this form to keep.

Signature:..........................................................................................

Date:..........................

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 47360883). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Pre-screening Questionnaire

Walker ID: ______________________

Sex: _____________

Age: _____________

Preferred Acting Method: ________________________________

Formal Acting Training (years):
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________

Acting Experience (years): ________________________________
Participant Information Sheet

“The Perception of Emotion from Walking Style”

Ethics Approval: HREC 06/154

Rationale for the study
This research is designed to increase understanding of how we perceive emotion in a person as they walk.

What you will be asked to do
Your role as a participant will be to watch a series of video displays of individuals walking. You will be asked to identify which emotion the walker is expressing. You will also be asked to rate how intense the emotion that each walker is expressing.

Participation is voluntary
Participation in this study is voluntary and you may withdraw at anytime without penalty/adverse consequences or reason. All information gathered will be strictly confidential and no published information can be used to identify you. Copies of the research data will be stored under password on a computer, and hard copies stored in a locked filing cabinet in the laboratory of the primary researcher.

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Participant Consent Form

“The Perception of Emotion from Walking Style”

Ethics Approval: HREC 06/145

I, __________________________________________, have read and understood the information in the plain language statement, and any questions I have asked have been answered to my satisfaction. I understand that my participation is voluntary and understand that I can withdraw at any time. I have been given a copy of this form to keep.

Signature:........................................................................................................

Date:..........................

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Identification Strategies Questionnaire

On reflection, what strategies do you think you used for judging which emotion each walker was feeling? For example, did you pay attention to a particular part of the display? For emotion categories where you used no particular strategy, but rather guessing was the strategy used, then this should be explicitly stated.

**Happy**

___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________

**Sad**

___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________

**Anger**

___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________

**Fear**

___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
___________________________________________________________________________________
Participant Information Sheet

“Is Affect Perceived Through the Kinematics of Gait”

Ethics Approval: HREC 06/154

Rationale for the study
This research is designed to increase understanding of how we perceive emotion in a person as they walk.

What you will be asked to do
Your role as a participant will be to watch a series of point light displays (points of light representing joints on a person’s body) of individuals walking. You will be asked to identify which emotion the walker is expressing. You will also be asked to rate how intense the emotion that each walker is expressing.

Participation is voluntary
Participation in this study is voluntary and you may withdraw at anytime without penalty/adverse consequences or reason. All information gathered will be strictly confidential and no published information can be used to identify you. Copies of the research data will be stored under password on a computer, and hard copies stored in a locked filing cabinet in the laboratory of the primary researcher.

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NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 4570 1136). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Participant Consent Form

“I Affect Perceived Through the Kinematics of Gait”

Ethics Approval: HREC 06/154

I,_________________________________________, have read and understood the information in the plain language statement, and any questions I have asked have been answered to my satisfaction. I understand that my participation is voluntary and understand that I can withdraw at any time. I have been given a copy of this form to keep.

Signature:..........................................................................................

Date:..........................

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 47360883). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Shaun Halovic
PH: 0416036183

Participant Information Sheet

“Is Affect Perceived Through the Kinematics of Gait”

Ethics Approval: HREC 07/102

Rationale for the study
This research is designed to increase understanding of how we perceive emotion in a person as they walk.

What you will be asked to do
Your role as a participant will be to watch a series of point light displays (points of light representing joints on a person’s body) of individuals walking. You will be asked to identify which emotion the walker is expressing.

Participation is voluntary
Participation in this study is voluntary and you may withdraw at anytime without penalty/adverse consequences or reason. All information gathered will be strictly confidential and no published information can be used to identify you. Copies of the research data will be stored under password on a computer, and hard copies stored in a locked filing cabinet in the laboratory of the primary researcher.

The findings of this research will be submitted for a PhD thesis assessment and may lead to professional publication.

Who is running the research
This research is being conducted by a PhD student of the name Shaun Halovic at the University of Western Sydney. Any queries about the research should be directed to Shaun Halovic (ph: 0416036183).

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 4570 1136). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Participant Consent Form

“I’s Affect Perceived Through the Kinematics of Gait”

Ethics Approval: HREC 07/102

I, __________________________________________, have read and understood the information in the plain language statement, and any questions I have asked have been answered to my satisfaction. I understand that my participation is voluntary and understand that I can withdraw at any time. I have been given a copy of this form to keep.

Signature:..........................................................................................

Date:..........................

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 47360883). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Participant Information Sheet

“The Influence of Adaptation Aftereffects on the Perception of Emotions from Walking Style”

Ethics Approval: H6226

Rationale for the study
This research is designed to increase understanding of how we perceive emotion in a person as they walk.

What you will be asked to do
Your role as a participant will be to watch a series of point-light displays. The point-light displays will be shown in consecutive pairs. The first of the pair will be shown as either random dots or of individuals walking. The second of the pair will always show a point-light walker. You will be asked to identify which emotion the second walker is expressing.

Participation is voluntary
Participation in this study is voluntary and you may withdraw at anytime without penalty/adverse consequences or reason. All information gathered will be strictly confidential and no published information can be used to identify you. Copies of the research data will be stored under password on a computer, and hard copies stored in a locked filing cabinet in the laboratory of the primary researcher.

The findings of this research will be submitted for a PhD thesis assessment and may lead to professional publication.

Who is running the research
This research is being conducted by a PhD student of the name Shaun Halovic at the University of Western Sydney. Any queries about the research should be directed to Shaun Halovic (ph: 0416036183).

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 4570 1136). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Shaun Halovic
PH: 0416036183

Participant Consent Form

“The Influence of Adaptation Aftereffects on the Perception of Emotions from Walking Style”

Ethics Approval: H6226

I,_________________________________________, have read and understood the information in the plain language statement, and any questions I have asked have been answered to my satisfaction. I understand that my participation is voluntary and understand that I can withdraw at any time. I have been given a copy of this form to keep.

Signature:..........................................................................................

Date:..........................

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 47360883). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Participant Information Sheet

“The Influence of Adaptation Aftereffects on the Perception of Emotions from Walking Style”

Ethics Approval: H6226

Rationale for the study

This research is designed to increase understanding of how we perceive emotion in a person as they walk.

What you will be asked to do

Your role as a participant will be to watch a series of point-light displays of individuals walking. The point-light displays will be shown as consecutive pairs. You will be asked to identify which emotion the second point-light walker is expressing.

Participation is voluntary

Participation in this study is voluntary and you may withdraw at anytime without penalty/adverse consequences or reason. All information gathered will be strictly confidential and no published information can be used to identify you. Copies of the research data will be stored under password on a computer, and hard copies stored in a locked filing cabinet in the laboratory of the primary researcher.

The findings of this research will be submitted for a PhD thesis assessment and may lead to professional publication.

Who is running the research

This research is being conducted by a PhD student of the name Shaun Halovic at the University of Western Sydney. Any queries about the research should be directed to Shaun Halovic (ph: 0416036183).

NOTE: This study has been approved by the University of Western Sydney Human Research Ethics Committee. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Research Ethics Officers (tel: 02 4570 1136). Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Shaun Halovic  
PH: 0416036183

Participant Consent Form

“The Influence of Adaptation Aftereffects on the Perception of Emotions from Walking Style”

Ethics Approval: H6226

I,________________________________________, have read and understood the information in the plain language statement, and any questions I have asked have been answered to my satisfaction. I understand that my participation is voluntary and understand that I can withdraw at any time. I have been given a copy of this form to keep.

Signature:..........................................................................................

Date:..........................

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Rationale for the study
This research is designed to increase understanding of how we perceive emotion in a person as they walk.

What you will be asked to do
Your role as a participant will be to watch a series of point-light displays of individuals walking. The point-light walkers will be shown as consecutive pairs with a brief interlude between them. You will be asked to identify which emotion the second point-light walker is expressing.

Participation is voluntary
Participation in this study is voluntary and you may withdraw at anytime without penalty/adverse consequences or reason. All information gathered will be strictly confidential and no published information can be used to identify you. Copies of the research data will be stored under password on a computer, and hard copies stored in a locked filing cabinet in the laboratory of the primary researcher.

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