CHAPTER 14

Seeing Human Movement as Inherently Social

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THE OBJECTIFICATION OF HUMAN MOVEMENT

For many decades, vision scientists objectified the human body. That is, studies of the perception of the human body, in motion and in static postures, adopted the same theoretical approaches and experimental methodologies as those used in the study of object perception. There are certainly several reasons for this, one being historical. Gunnar Johansson, the researcher who first captured the attention of vision scientists with point-light displays of human movement (see Figure 14.1), does not appear to have been particularly interested in the visual perception of human motion, *per se*. Instead, his primary goal was to define the motion processing algorithms that direct grouping for all categories of visual motion (Johannson, 1976). Nonetheless, Johansson (1973; 1976) discovered that in as little as 200 msec, observers could identify specific human actions from the movements of a few points depicting the dynamic locations of a moving person’s major joints and head. Johansson (1973) attributed the especially vivid percepts that observers of point-light displays of human movement readily experience to observers’ extensive prior visual experience with those movements. Such a conclusion suggests that, at least in terms of visual processing, there is nothing particularly special or distinctive about human action other than its prevalence. Thus, the study of human motion perception started with the assumption that the human body is just another complex object.

that "processes" all

Johansson was certainly not alone in his approach to the human visual system as a general purpose processor that ’s all categories of the visual stimuli in the same way. Indeed, many classic models of the visual system have made the same assumption. For example, David Marr (1982) developed a very influential model of the visual system as a hierarchical system that applies a fixed set of visual processes to all retinal images. Roger Shepard (1984) targeted visual motion perception directly and argued that all types of visual motion are similarly analyzed. This argument continues to the present day as evidence is interpreted as suggesting that the visual perception of human movement does not differ from the visual perception of moving objects and surfaces (e.g., Hiris, 2007).

Of course, not all scientists understood the visual system in this way. J. J. and Eleanor Gibson conceptualized the visual system in functional terms. According to their approaches, perception and action are intrinsically coupled such that visual perception depends upon the observer’s motor activities and capabilities (e.g., E. Gibson, 1969; J.J. Gibson, 1986). Thus, Gibsonian theories emphasize the functional relationships between what a person sees and what that person can do, or is doing. On a functional level, human movement must be defined as social, especially when compared to the

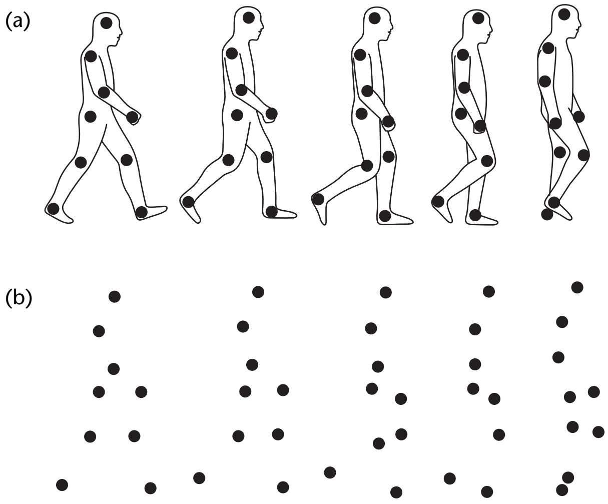

Figure 14.1 (a) A series of static outlines depicting the changing shape of a walking person's body with points positioned on the major joints and head. (b) A point light walker is constructed by removing everything from each image except the points. When static, these displays are difficult to interpret. However, once set in motion, observers readily detect the presence of a walking person.

movements of objects such as wind blown trees and crashing waves. Because social processes drive much of human behavior, social psychologists with a Gibsonian approach began to study the relationships between social processes and visual perception (e.g., McArthur & Baron, 1983; Zebrowitz & Collins, 1997). The field of social neuroscience emerged around this same time and one of the field's pioneering researchers, Leslie Brothers (1997; ~~this~~ v[illegible] vincingly argued that neural syste[illegible] be understood independently of t[illegible] cesses that shaped them. Indeed, [illegible] that neuroscientists are doomed [illegible] their quest to understand neuron[illegible] as long as they ignore social constraints on the development and evolution of the brain.

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The ways in which individuals hold and move their facial features conveys extensive social information and, as several of the chapters in this text have beautifully demonstrated, the human visual system is finely tuned for the detection and analysis of facial information. However, social cues are not limited to the face and the visibility of a social partner's facial features is not guaranteed. The high spatial frequency content of a face become less detectable and face perception becomes difficult, for example, when light levels decrease, individuals turn their heads, and distance between the observer and an observed face increases (e.g., Fiorentini, Maffei, & Sandini, 1983; Goffaux & Rossion, 2006). Yet, social interaction certainly doesn't stop in the evening or when heads turn. Because bodies are bigger than faces, observers can detect social information from bodily motions whenever facial cues are difficult to detect. As will be described later in this chapter and in the chapter by Kerri Johnson (this volume), such large-scale signals convey a surpris- [illegible] of socially relevant information. Of [illegible]ces are almost always attached to bod- [illegible]e chapter by Beatrice de Gelder (this [illegible] makes clear, visual percepts of faces [illegible]es are interdependent. Nonetheless, [illegible]ter will focus on the visual perception of whole b[illegible]

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To better understand how the visual system s the movements of the human body, four topics will be addressed. Section 2 describes differences between the perceptual and neurophysiological analyses of moving people and moving objects. The goal of this section will be to make a convincing argument against vision scientists' general tendency to objectify human movement. Indeed, evidence will be reviewed that suggests that the human visual system uses distinct mechanisms during the perception of objects and people in motion. Next, Section 3 will briefly describe some of the social and emotion information that observers can detect from highly degraded displays of human motion.

For a more extension discussion of this topic, the reader should consult the chapter by Kerri Johnson in this [illegible] on an argument tha[illegible] sci-entists may find disagreeable. That is, classic models of the visual system are largely modular in that visual perception depends exclusively upon visual processes (e.g., Fodor & Pylyshyn, 1981). The output of visual processes may be passed onto higher-level mechanisms that process social and cognitive information, but those higher-level processes cannot feed back to change visual processes. Instead, social and cognitive processes can only change the decisions that observers make about their percepts. In conflict with this traditionally bottom-up approach, this section will review evidence suggesting that social and emotional processes change the visual perception, per se, of human movement. Section 5 describes investigations of the relationships between observers' social capabilities and their visual sensitivity to other people's actions.

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DIFFERENCES IN THE VISUAL ANALYSIS OF HUMAN AND OBJECT MOVEMENT

Movement, by definition, is a change in location over time. Therefore, the visual perception of motion depends upon analyses of luminance across both space and time. Evidence from several studies, summarized below, indicates that these processes of spatio-temporal integration differ during the perception of object movement and physically possible human movement.

The integration of visual motion information over space has been studied with point-light displays and multiple-aperture displays. The point-light technique that Gunnar Johansson made famous in the vision sciences during the 1970s was a modific[illegible] oped by Etienne Jule[illegible] study of locomotio[illegible] (Marey, 1895/1972). Working during the same period as Eadweard Muybridge (1830–1904), Marey developed a system for achieving multiple photographic exposures on a single plate. The resulting images were too blurry for Marey's measurement needs so he added luminous markings or small lights to the actor whose movements he wanted to measure (Verfaillie, 2000). In this way, measurements of limb displacements over time became more accurate. Johansson (1976) adapted this technique for the study of visual motion perception and over the subsequent decades, scientists from around the world used point-light displays to study the perception of human motion (see Blake & Shiffrar, 2007 for review). Such research has shown that the visual perception of point-light depictions of human motion depends upon analyses that are spatially global, rather than local or point-by-point. For example, when a point-light defined person appears to walk within a point-light mask, as shown in Figure 14.2, observers can reliably detect the walking person (e.g., Bertenthal & Pinto, 1994; Cutting, Moore, & Morrison, 1988). Because the points in the mask have the same size, luminance, and velocities as the points defining the walker (indeed, masks are generally made by duplicating the point-light walker and then scrambling the starting locations of that walker's points), local analyses of the motions of individual points cannot be used to detect the walker. Instead, only the global spatiotemporal configuration of the points distinguishes the walker from the mask. As a result, detection of point-light walkers in a mask depends upon on the integration of motion cues over space (Bertenthal & Pinto 1994). When the same masking technique is used with complex, nonhuman motions (Hiris, Krebeck, Edmonds, & Stout, 2005), detection sensitivity drops significantly. This combination of results suggests that visual sensitivity to human and object movements differ. We'll return to this point in Section 4.

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Studies us[illegible]ys pro-vide addition[illegible] visual anal[illegible] larger [illegible]xtents than object motion. Because all [illegible]ystems measure motion through spatially limited receptors, motion information falling outside of the receptive fields cannot be measured. This produces inherently ambiguous r[illegible] a[illegible]

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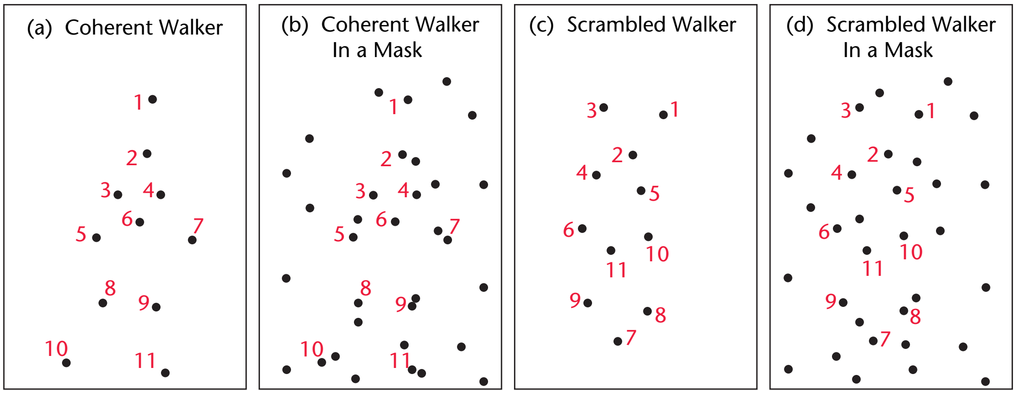

Figure 14.2 (a) Visual sensitivity to point-light displays of human motion is frequently measured with motion coherence discrimination tasks. Within the tasks, half of the trials depict a coherent point light walker. (c) In the other half of the trials, the starting locations of the points are scrambled. (b,d) Then, these scrambled and coherent point-light walkers are presented within point-light masks. The masks are usually constructed by duplicating the walker and then scrambling that duplicate walker(s). As a result, the same motion energy is present in the mask and walkers (whether coherent or scrambled).

spatial locations provides one solution to this so-called aperture problem (Hildreth, 1984). However, this solution comes with its own set of problems because while motion integration may be needed to integrate motion measurements within an object, it must often be inhibited across different objects (Shiffrar & Lorenceau, 1996). As a result, the visual system must strike a delicate balance between motion integration and motion segmentation. Interestingly, the visual system does not appear to adopt the same balance point for human motion and object motion. When observers view a walking person through a set of apertures, they perceive coherent motion, suggesting that they have integrated motion information across the disconnected regions of space. However, when observers view complex objects, such as cars or scissors, through apertures, they perceive incoherent motion that indicates a lack of integration across space (Shiffrar, Lichtey, & Heptulla-Chatterjee, 1997). Interestingly, only physically possible human motions appear to be integrated across such spatially extended windows. Human movements that are impossibly slow, fast, or oriented appear to be analyzed by local motion mechanisms (Shiffrar et al., 1997).

Neurophysiological evidence further supports the hypothesis that the perception of human movement depends upon the global integration of motion measurements. For example, the perception of point-light displays of human motion is associated with elevated activity in the posterior region of the superior temporal sulcus or STSp (e.g., Bonda, Petrides, Ostry, & Evans, 1996, Puce & Perrett, 2003). If STSp activity simply depended upon the movements of any individual points, then shuffling the locations of those points should have no impact on STSp activity. Instead, when the point-lights that def [illegible] rambled, so that the [illegible] ries remain unchang [illegible] structure of the points is broken, STSp activity drops significantly (Grossman et al., 2000). Thus, the neural processes underlying action perception in point-light displays appear to depend upon the global relationships between moving points.

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Magnetoencephalography (MEG), a brain imaging technique with high temporal resolution, has been used to directly compare neural activity during the perception of point-light displays of human motion and object motion. Resultant analyses have identified both overlapping and divergent areas of neural activity.

Specifically, while human motion and object motion appear to be initially analyzed by overlapping neural areas (given the spatial resolution of MEG), their analyses diverge about 200 msec after stimulus onset (Virji-Babul et al., 2007). Only human motion is associated with subsequent activity in the right temporal lobe, suggesting that the visual system differentiates human and object motion.

As stated earlier, the visual perception of movement also involves the integration of information over time. Apparent motion, or the illusion of movement between brief static images (Wertheimer, 1912), is a classic technique for investigating the temporal characteristics of visual motion perception. In classic demonstrations of apparent motion, two spatially separated objects are sequentially presented. Within certain temporal parameters, this sequential presentation of static objects gives rise to the perception of a single moving object. While there are an infinite number of paths that might connect any two object locations, perceived paths of apparent motion usually follow the shortest possible path (Burt & Sperling, 1981). Because human limbs follow approximately pendular trajectories (because we are jointed), human movement cannot follow direct, rectilinear trajectories. Consistent with this conflict, something interesting can happen when images of people replace images of objects in apparent motion displays.

When observers view apparent motion displays depicting a person with a limb in two different positions (Figure 14.3), their apparent motion percepts depend upon the display rate. When pictures of the human body are presented at temporal rates that fall within the temporal range for the production of normal human actions, observers tend to perceive paths of apparent motion that are consistent with the biomechanical constraints on human movement (Shiffrar & Freyd, 1990; 1993). That is, they perceive physically possible paths of apparent human motion rather than the shortest, physically impossible path of human movement. When these same pictures are presented at rates that are inconsistent with the possible speeds of human movement, then observers perceive the shortest possible paths of apparent motion, even if those paths are physically impossible. Conversely, when control objects are shown at different apparent motion display rates, observers always perceive the shortest possible paths of apparent motion. This pattern of results suggests that human movement is analyzed by motion processes that operate over relatively large temporal windows and that take into account the biomechanical limitations of the human body. Brain imaging data support this conclusion (Stevens, Fonlupt, Shiffrar, Decety, 2000). When observers of apparent motion displays perceive physically possible paths of limb movement (slower display rates), neural activity increases in motor planning areas and body representation areas. When display rates increase, so that observers perceive physically impossible paths of apparent human motion, neural activity does not increase in these areas. Furthermore, these areas remain relatively inactive during

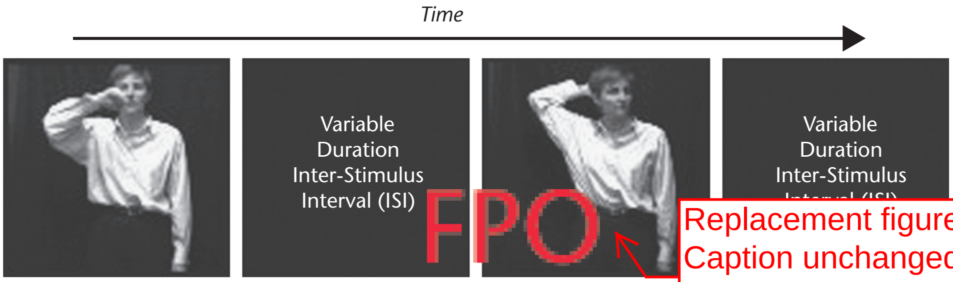

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Figure 14.3 An apparent motion display of an arm on either side of a person's head. At long ISIs, the arm appears to move around the head. At short ISIs, the arm appears to move through the head following the shortest possible path of apparent motion.

the perception of objects in apparent motion. Such resu of physic upon neural mechanisms that are not involved in the visual perception of object movement or impossible human movement.

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THE VISUAL DETECTION OF SOCIAL AND EMOTIONAL INFORMATION FROM HUMAN MOVEMENT

Most studies of the visual perception of human movement have focused on the detection of physical features. Given the traditional assumption that object movement and human body movement are similarly, if not identically, processed, it is not surprising that the perception of physical features (shared by objects and humans) has been emphasized. For example, participants viewing point-light displays of human movement are frequently asked to discriminate the location, presence, coherence, or direction of their moving target. A few studies have asked observers to categorize the actions that a point-light actor performs (e.g., Dittrich, 1993).

Importantly, an impressive variety of social features can also be detected from degraded displays of human movement. For example, naïve observers are above chance in their ability to detect a walking person's gender from point-light displays (Barclay, Cutting, & Kozlowski, 1978; Pollick, Kay, Heim, & Stringer, 2005; Johnson, this volume). An individual's sexual orientati levels (A Ambady, this volume, Johnson, Gill, Reichman, & Tassinary, 2007; Johnson, this volume). Numerous studies have shown that observers can recognize the identities of other people, as well as themselves from dynamic, but not static, point-light displ ki, 1977; Jacobs, Pin h, Daum, & Troje, 2 & Shiffrar,2005). Other studies have demonstrated that untrained observers can detect another person's potential reproductive fitness (Brown et al., 2005), degree of psychological openness (Brownlow, Dixon, Egbert, & Radcliffe, 1997), age and social dominance (Montepare & owitz-McArthur, 1988), and vulnerability ack (Gunns, Johnston, & Hudson, 2002) in point-light displays. Such findings indicate that when people move, their movements express extensive social information that the human visual system is capable of detecting.

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Intentionality is another complex psychological state that naïve observers can detect in point-light displays of human movement. In a now classic study, individuals were asked to move in a manner that was either consistent or inconsistent with their own gender. When naïve observers viewed point-light displays of these deceptive actions, they readily detected the deceptive intentions (Runeson & Frykholm, 1983). In this same set of studies, point-light displays were created of people who lifted an empty box normally and in a manner that erroneously suggested that the box was heavy. Again, observers accurately detected the deceitful lifts. Visual sensitivity to the intention to deceive is experience dependent. For example, the accuracy with which a stationary observer can determine whether a point-light defined basketball player i or to fake a pass depends upon the observer's motor and visual experience playing the game of basketball (Sebanz & Shiffrar, 2008).

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Affective state can also be reliably detected in point-light displays of human movement. Observers can readily identify the emotions felt by point-light defined individuals who move their entire bodies (Atkinson, Dittrich, Gemmell, & Young, 2004; Dittrich et al., 1996). Even more impressively, naïve observers can identify the emotional state of a person knocking on a door when only the knocking, point-light arm is visible (Pollick, Paterson, Bruderlin, & Sanford, 2001). The affective states of point-light defined individuals appear to be most recognizable when they are presented within a consistent social context. For example, when a point-light defined person expresses some emotional state during an interaction with another person, that emotional state is most accurately detected when point-light displays show both individuals rather than only the emotional individual (Clarke, Bradshaw, Field, Hampson,

& Rose, 2005). Thus, social and emotional cues appear to be integrated during the visual analysis of human movement. Neurophysiological evidence supports this conclusion. The STSp is required for the visual perception of point-light displays of human movement (Saygin, 2007). Interestingly, the STSp responds more strongly during the perception of emotional than instrumental actions (Gallagher & Frith, 2004). Furthermore, STSp activity is clearly involved in the analysis of visual cues to socially relevant information (e.g., Allison, Puce, & McCarthy, 2000). Thus, overlapping neural circuitry is involved in the visual perception of emotion, social cues, and human action (Puce & Perrett, 2003). Because people express emotional states and behave socially, whereas physical objects do not, these results provide additional evidence that the human visual system differentiates its analyses of human and object motion.

To interact successfully with other people, it would be helpful if one could detect other people's social, affective, and intentional states. The results summarized earlier indicate that such detection is possible with only a few moving points. Sensitivity to social and emotional cues in significantly degraded visual stimuli suggests that the human visual system is well tuned for the detection and analyses of essentially human information. Thus, the results summarized here suggest that the visual system plays a critical role in allowing and promoting human interaction.

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SOCIAL AND EMOTIONAL PROCESSES CHANGE HUMAN MOVEMENT PERCEPTION

The previous section focused on the types of social and affective information that naïve human observers can detect from whole body human movements, especially those depicted in point-light displays. The ability to detect such high-level information presents no challenge to traditional models of the visual system. According to such modular, feed-forward models, the outputs of low-level visual processes are simply passed along to subsequent social and affective mechanisms that extract socially relevant information. However, although the visual system has been traditionally understood as a feed-forward system, neurophysiological support for feedback processes has long been available (e.g., Rockland & Pandya, 1979). At least within the visual system, feedback connections appear to be more extensive than feedforward connections (Salin & Bullier, 1995). Interestingly, and contrary to many long held assumptions, feedback connections can modify lower level visual processes very quickly, indeed, in as little as 10 msec (Hupe et al., 2001). Recent researchers have made significant advances in understanding core visual processes, such as object recognition, by taking feedback or top-down processing into account (e.g., Kveraga, Ghuman, & Bar, 2007). The visual area that is critical for the perception of point-light displays of human motion—namely, the STSp (Saygin, 2007)—is tightly connected with the neural areas involved in social and emotional processes (e.g., Adolphs, 1999; Allison et al., 2000). If feedback from social and emotional mechanisms can rapidly modify lower-level visual analyses, then one would expect to find that social and emotional information can change visual sensitivity to human movement. This proposal was tested in the following experiments.

Social Processes

Does the visual perception of human movement change as a function of the social context within which that movement appears? Recall that social context enhances visual sensitivity to a point-light actor's emotional state (Clarke et al., 2005). Furthermore, fMRI data suggest that people spontaneously and continuously monitor visual scenes for their social content. When people passively observe a human action within a social context, increases in neural activity are found in the medial parietal and medial prefrontal cortices, areas that are interconnected with the STS (Iacoboni et al., 2004). However, when that same human action is presented in social isolation, that is, in the absence of another person, no activation increases are found. Thus, something changes when human actions are presented within social contexts. But, does visual sensitivity to human movement change, per se?

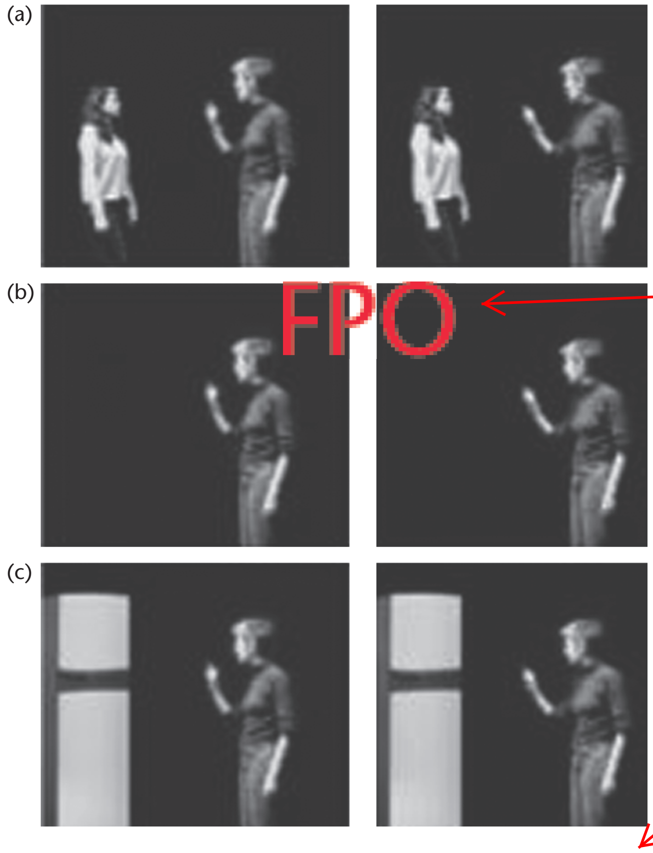

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Figure 14.4 Apparent motion stimuli adapted from Chouchourelou & Shiffrar (2008). The same human movement appears in three different static contexts. (a) On the top row, two frames of an apparent motion sequence depict a person on the right gesturing towards a static person. Notice that the person on the left remains stationary while there is a displacement of the right arm of the other person. (b) The same human gesture appears in isolation or (c) within the context of a stationary object. When asked to judge how much motion is depicted in these apparent motion displays, observers who view the movements within social contexts, as in (a), report the perception of significantly more motion than observers who view the identical displacements in non-social contexts, as in b and c.

To determine whether social context influences the visual perception of human movement, Areti Chouchourelou conducted the following studies of apparent motion perception. In the first study, naïve participants viewed a set of two-frame apparent motion stimuli depicting a woman performing various simple actions, such as reaching, pointing, or kicking (Figure 14.4). These stimuli were constructed by filming two people interacting with each other. The resulting digital video clips were systematically edited. First, two static frames, separated by 150 msec, were pulled from the video clip of each action. These static frames were edited so that everything from each frame was removed except the person performing the action. Then, graphic editing was used so that each two-frame action sequence appeared in isolation, directed toward a static object, or directed toward a static person. The assumption was made that the presence of another person created a social context, whereas the presence of an object did not.

Each participant saw all of the actions presented in one of the different contexts. Across trials, the display rate of the apparent motion stimuli was varied. Each picture in an apparent motion stimulus pair was displayed for a 100 msec and the time between each picture, or inter-stimulus-interval, ranged from 10 to 600 msec. Participants were lead to believe that they were taking part in a study of the dynamic image quality of various computer monitors. That is, the phenomenon of apparent motion was explained to them. Then participants were told that monitors vary in the quality of apparent motion that they produce. Participants were then asked to watch various apparent motion sequences for 5 seconds each and to rate how much motion they saw on a scale from 1 (no motion) to 7 (smooth motion) in each apparent motion sequence. Participants who viewed the actions within a soc[illegible]ent motion displays as conveying significantly more motion than participants who viewed the same actions in the non-social contexts (Chouchourelou & Shiffrar, 2008). That is, even though participants viewed identical physical displacements, because the same human displacements appeared in every context, motion percepts were enhanced for social human actions relative to isolated actions or actions directed toward objects. This result is consistent with the hypothesis that social processes change fundamental aspects of the visual perception of human movement.

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There is, however, an alternative interpretation of the these results. That is, all of the apparent motion stimuli were constructed from human actions that were originally directed toward another person. So maybe more compelling motion percepts were reported in the social context simply because the actions made the most sense within that context. To address this confound, another study was conducted. Stimulus construction began with the digital videotaping of human actions directed toward objects and toward people. As before, two static frames were pulled from the video depicting each action. These frames were edited so that only the central moving person was visible. Then, a pilot study was conducted with these two sets of isolated actions. As before, naïve observers rated the amount of movement (as compared to stationary flashing) they perceived when they viewed each action in isolation. The resulting judgments were used to equate stimuli for the amount of perceived movement they produced. Once the stimuli were equated, graphic editing was used to reintroduce the stationary images of the original object or person toward which each action had been directed. Then a new group of participants rated the amount of movement they observed in the two types of apparent motion sequences. The results of this experiment showed that naïve observers saw significantly more motion w[illegible] displays depicted actions directed toward another person than actions directed toward an object (Chouchourelou & Shiffrar, 2008). This finding is consistent with the hypothesis that the neural analysis of object-directed actions differs from the analysis of person-directed actions (Jacobs & Jeannerod, 2003). Indeed, the results of these two studies suggest that social processes, per se, spontaneously enhance the visual analysis of human motion. Given that human movement is an inherently social stimulus, it certainly makes sense that social context would contribute to its analysis.

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Emotional Processes

Is the visual analysis of human action similarly modulated by the emotional content of that action? Neuroanatomical connections between visual and emotional areas suggest that such modulation is possible. The STSp, a visual area that plays a critical role in the perception of human movement (e.g., Grossman et al., 2000; Saygin, 2007), is extensively interconnected with the amygdala, a region of the limbic system that is involved in the analysis of the emotional content of sensory information (Brothers, 1997; Amaral, 2003). Recurrent processing between the amygdala and the STSp (Amaral, 2003) raises the possibility that the visual analysis of human movement is systematically modified by the emotional content of that movement. A series of psychophysical studies by Chouchourelou and her colleagues (2006) produced data that are consistent with this prediction. Stimulus construction began when trained actors walked within a motion capture system while expressing five different emotional states: happy, sad, angry, fearful, and neutral. The motion-capture data were converted into point-light displays. In the first study, naïve observers viewed the emotional point-light walkers one by one and reported each walker's emotional state. Performance in this emotion recognition task was well above chance, confirming previous findings (Atkinson et al., 2004; Dittrich et al., 1996). Then, point-light movies with at least 83 percent interparticipant agreement in this emotion recognition task were selected for use in subsequent studies.

In the main study, point-light walkers with readily recognizable emotional states were placed within specially constructed point-light masks. Each walker was presented within its own mask. Each mask was constructed by scrambling the starting locations of the points defining the walker that appeared within that mask. Thus, a happy walker was presented within its own happy mask and a sad walker was presented within its own sad mask. As a result, for each stimulus, there was no net velocity difference between the points defining the walker and the points defining the mask. This manipu[illegible] important because different emotions [illegible] ciated with different patterns of movement (Pollick et al., 2001). For example, sad people tend to move slowly whereas happy people move more quickly. The technique described ensured that walker detection performance could not be driven by the differences in gait velocity associated with different emotion[illegible]

In one half of the trials, a [illegible] walker was present with its point-light mask. On the other half of the trials, the walker was scrambled, like the mask, so that no coherent walker was present. Participants viewed each masked display and reported whether a coherent point-light walker was present within the mask. No feedback was provided. Importantly, participants were not asked to judge any emotional information. Indeed, the experimenter never mentioned emotion. Participants simply reported whether a walker was present or absent. The results showed that walker detection was systematically modulated by the emotional content of the walkers' gaits. Specifically, participants demonstrated the greatest visual sensitivity to the presence of angry walkers (Chouchourelou, Matsuka, Harber, & Shiffrar, 2006). This finding is particularly interesting because researchers have argued that the amygdala is most responsive to potentially threatening stimuli (Amaral, 2003; Whalen et al., 2004). An angry person is clearly a threatening stimulus. Thus, these results suggest that emotional processes automatically contribute to and indeed help to define visual sensitivity to the actions of other people.

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SOCIAL BEHAVIOR AND THE DETECTION OF HUMAN MOVEMENT

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Most researchers who study the visual perception of human movement motivate their experiments with the argument that successful social behavior requires the rapid and accurate perception of other people's actions (e.g., Blake & Shiffrar, 2007). Although this assertion seems simple enough, it nonetheless predicts that there is a direct relationship between visual sensitivity [illegible]vement and social behavior. This [illegible] been tested with studies of the perceptual capabilities of people with Autism spectrum disorder (ASD). ASD is an inherently social disorder that affects, to varying degrees, an individual's ability to communicate and interact with other people (DSM-IV TR, 2000). If visual sensitivity to human action is directly related to successful social behavior, then observers with ASD should show defici[illegible] observers, in their visual [illegible] movement. Yet, previou[illegible] have not resolved whether observers with ASD are compromised in their visual sensitivity to point-light displays of human movement.

Capitalize Spectrum Disorder

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Autism Spectrum Disorder

Moore, Hobson, and Lee (1997) were the first to examine the visual perception of human movement by observers with ASD. In their studies, children and adolescents with autism or non-autistic retardation viewed variable-duration point-light displays of people and objects and verbally described each display. No significant differences were found in the amount of time that observers with ASD and controls needed to accurately describe each movie's content. Observers with ASD did show, however, a nonsignificant trend toward delayed recognition of moving people when defined by only 5 point lights. Children with ASD were significantly less likely to describe a point-light person's emotional state (e.g., happy, sad) than nonautistic control observers, but those with ASD showed no difference from controls in their tendency to describe the type of action being performed (e.g., walking, running). This finding was replicated with observers with Asperger's Syndrome (Hubert et al., 2007). These researchers concluded that young observers with ASD exhibit normal perceptual sensitivity to human movement, *per se*, but they exhibit impairments in the attribution of mental states to human movement. However, because autism is strongly associated with language deficits (DSM-IV-TR, 2000), it is difficult to interpret the results of verbal measures.

Motivated by concerns about the sensitivity of descriptive measures, Blake and his colleagues (2003) conducted a two-alternative forced-choice study of visual sensitivity to point-light displays of human motion by young observers with ASD and matched controls. On half of the trials, observers viewed brief point-light movies of a person performing some action such as running, throwing or jumping. On the other half of the trials, the points defining the point-light actors were temporally scrambled to disrupt the hierarchy of pendular motions that define the human body. Children viewed these point-light movies in random order and reported whether the dots moved like a person. As a control for grouping processes, these same observers also performed a global form task by pointing to which of four quadrants contained a static, circular target shape among an array of distractor line segments. These researchers found that children with ASD performed the human motion detection task more poorly than matched controls and the global form detection task as well as controls. Impressively, a significant correlation was found between children's severity of autism and their performance on the human motion detection task. These researchers concluded that children with ASD are compromised in their ability to perceive coherent human motion. However, alternative interpretations remain. Given the diagnostic language and communication impairments in ASD, children with ASD may have performed relatively poorly on the human motion task compared to the static form task because the first required a verbal response whereas the second did not. Furthermore, because a static control task was used, the results of this experiment are consistent with the hypothesis that observers with ASD show deficits in global motion processing, in general, and not in human motion processing, in specific. Consistent with this alternative explanation, several studies have reported that observers with ASD show deficits in their ability to perceive global motion in random dot cinematograms (Milne et al., 2002; Pellicano et al., 2005; Spencer et al., 2000).

There is, nonetheless, neurophysiological evidence suggesting that autism does impact the visual analysis of human movement. Recent studies have identified associations between ASD and abnormalities in the STSp (e.g., Boddaert et al., 2004; Pelphrey, Morris, McCarthy, & LaBar, 2007). If abnormalities in the STSp impact the visual analysis of human movement, then observers with ASD should show selective deficits in their visual perception of human movement.

Martha Kaiser and her colleagues recently began a series of experiments designed to avoid the pitfalls that have complicated previous studies. In these studies, observers with ASD and controls are asked to perform a motion coherence discrimination task with point-light depictions of human motion and object motion. The human stimuli depict a point-light-defined person walking and/or reaching over to pick up an object. The object stimuli depict a point-light-defined tractor with a front bucket that moves forward while the bucket does or does not reach down to pick up an object. Across trials, these stimuli are presented as either coherent or scrambled by a rearrangement of the starting positions of the point-lights. In the human condition, participants report with a button press whether the point lights were stuck to a person. In the object condition, participants replace this reference with (Kaiser et al., 2010)

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similarly report whether the point lights were stuck to a tractor. The preliminary results (Kaiser & Shiffrar, 2007) indicate that observers with ASD and controls show no significant difference in their visual sensitivity to the presence of coherent object motion. Conversely, in the human motion condition, task performance by control observers is significantly better than performance by observers with ASD. These results suggest that observers with ASD have a specific deficit in their visual sensitivity to human motion. This deficit in visual sensitivity to human movement cannot be attributed to a general deficit in global motion perception because observers with ASD performed as well as typical observers in the tractor motion detection task. Furthermore, task performance in the human motion condition cannot be attributed to cognitive deficits in task comprehension or response production because the same task and response were used in the object motion condition where observers with ASD performed as well as controls. Such evidence supports the hypothesis that visual sensitivity to human movement is related to, or may even be a precursor to, successful social behavior.

Typical Observers

Although the described results are useful for understanding perceptual processing in autism, they do not inform us about the relationships between action perception and social behavior in typical observers. To address that issue, Kaiser took advantage of the fact that autistic symptoms appear in both clinical and nonclinical population [illegible]. In other words, aut [illegible] g typical, non autistic individuals. Interestingly, nonautistic scientists, mathematicians, and engineers exhibit more autistic traits than scholars in the humanities and social sciences (Baron-Cohen et al., 2001). The Autism-Spectrum Quotient or AQ is a short questionnaire that measures the extent to which individuals with normal IQs exhibit autistic traits (Baron-Cohen et al., 2001). To investigate the relationship, if any, between visual sensitivity to human movement and social behavior, typical university students performed the same point-light human-motion- and tractor-motion-detection tasks described already described and then completed the AQ questionnaire. The results showed that as scores on the AQ increased, indicating the increasing presence of autistic traits, performance on the human motion detection task decreased. Importantly, performance on the tractor motion detection task did not vary with scores on the AQ (Kaiser, Fermano, & Shiffrar, 2008). These data suggest that visual sensitivity to human motion is indeed related to social behavior in the typical population. The directionality of that relationship remains to be determined. That is, we do not yet know whether enhanced visual sensitivity to human movement promotes more successful social behavior or whether successful social behavior leads to improvements in visual sensitivity to human movement, or both.

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GENERAL CONCLUSION

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In conclusion, the results of the studies summarized here indicate that the visual perception of human motion differs in fundamental ways from the visual perception of object motion. First, multiple psychophysical measures indicate that visual analyses of human motion involve the integration of information over greater spatiotemporal extents than the visual analysis of complex object motion. One result of such expanded integration capacities may be the ability to tolerate more noise during action perception. The lifetime of visual experience that observers gain from watching the actions of other people likely enhances noise tolerance (Bulthoff, Bulthoff, & Sinha, 1998), as does disambiguating input from motor, social and emotional centers (see Blake & Shiffrar, 2007 for review). Second, neurophysiological evidence shows that distinct neural areas are involved in the visual analysis of human motion. Although the perception of meaningful objects and people in motion initially rely on overlapping mechanisms, divergent processing is found soon thereafter (Virji-Babul et al., 2007). Third, naïve observers are able to detect an impressive variety of surprisingly complex and subtle types of socially relevant information from the movements of the human body.

Obviously, the detection of such information in object motion is not possible because objects, unlike people, do not vary, for example, in their social dominance, sexual orientation, psychological openness, or affective state. Instead, the visual perception of dynamic stimuli that are structurally and/or biomechanically consistent with an observer's own body appears to trigger social, emotional, and motor analyses that help to define visual sensitivity to those stimuli (Shiffrar, 2006). This is not to say that objects cannot be interpreted as having human-like characteristics (Hieder & Simmel, 1944). Indeed, perception of geometric figures can trigger activity in the STSp (Castelli, Frith, Happe, & Frith, 2002). Fourth, social and emotional processes significantly modify visual sensitivity to human movement. The dynamic cues to emotion that are produced by an individual's bodily actions alter an observer's ability to detect the presence of that person's moving body. Furthermore, the ability to detect the presence of human motion within apparent motion displays depends upon the social context within which that motion is presented. And finally, visual sensitivity to the presence of coherent human movement, but not coherent object movement, correlates with observers' autistic tendencies. Because autism is an inherently social disorder (Schultz, 2005), this result suggests that an observer's social abilities are related to that observer's visual sensitivity to the actions of other people.

For the past several decades, vision scientists and psychologists have been fascinated by point-light displays of human movement. These displays are surprisingly engaging. The results of the studies described in this chapter suggest that point-light displays of human motion may be especially compelling because their visual analysis is deeply intertwined with human social behavior. Indeed, the human visual system appears to detect, reflect, and promote the com-

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