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Effects of aging on identifying emotions conveyed by point-light walkers

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Abstract

The visual system is able to recognize human motion simply from point lights attached to the major joints of an actor. Moreover, it has been shown that younger adults are able to recognize emotions from such dynamic point-light displays. Previous research has suggested that the ability to perceive emotional stimuli changes with age. For example, it has been shown that older adults are impaired in recognizing emotional expressions from static faces. In addition, it has been shown that older adults have difficulties perceiving visual motion, which might be helpful to recognize emotions from point-light displays. In the current study, four experiments were completed in which older and younger adults were asked to identify three emotions (happy, sad, and angry) displayed by four types of point-light walkers: upright and inverted normal walkers, which contained both local motion and global form information; upright scrambled walkers which contained only local motion information; and upright random-position walkers which contained only global form information. Overall, emotion discrimination accuracy was lower in older participants compared to younger participants, specifically when identifying sad and angry point-light walkers. Additionally, observers in both age groups were able to recognize emotions from all types of point-light walkers, suggesting that both older and younger adults are able to recognize emotions from point-light walkers on the basis of local motion or global form.

Keywords: Aging, Emotion Discrimination, Direction Discrimination, Point-Light Walkers, Biological Motion

Effects of aging on identifying emotions conveyed by point-light walkers

Normal healthy aging is associated with changes in a variety of perceptual and cognitive processes. One area of known impairment in older adults is the ability to recognize emotions (e.g., Brosgole & Weisman, 1995; Calder et al., 2003; Isaacowitz et al., 2007; Orgeta & Phillips, 2008; Sullivan & Ruffman, 2004; Sullivan, Ruffman, & Hutton, 2007). More specifically, older adults have greater difficulty recognizing the subtle differences among negative emotions such as anger, sadness and fear (Ruffman et al., 2008; Creighton, Sekuler & Bennett, 2012). Most previous studies of the effects of aging on the perception of emotions have concentrated on static facial expressions; however, motion influences the perception of emotion, especially for non-facial stimuli such as bodies. Despite the clear importance of motion information for the perception of emotion in younger observers (e.g., Atkinson et al., 2004), few studies have examined the effects of aging on the recognition of emotions from dynamic stimuli (Krendl & Ambady, 2010). Such an examination is particularly important because dynamic information may provide a mechanism for compensation in the identification of emotions among older observers. On the other hand, some aspects of motion perception have been shown to decline with age (Andersen & Ni, 2008; Atchley & Andersen, 1998; Bennett, Sekuler, & Sekuler, 2007; Gilmore, Wenk, Naylor, & Stuve, 1992; Norman, Ross, Hawkes, & Long, 2003; Snowden & Kavanagh, 2006; Trick & Silverman, 1991), which might limit the extent to which dynamic information could enhance emotion perception with age.

Point-light walkers have been used to study emotion recognition on the basis of body movement. First used by Johansson (1973), who attached reflectors to the major joints of a moving human body and showed that the stimulus could be identified as a human by grouping the local motion of the point-lights into a global percept of a moving figure, point-light walkers have been shown to convey information about the sex, identity, and also the emotional state of the person (e.g., Cutting and

Kozlowski, 1977; Kozlowski and Cutting, 1977; Dittrich et al., 1996). For example, Ruffman, Sullivan, and Dittrich (2009a) investigated emotion perception in aging using both full-body and point-light animations that displayed physical expressions of emotions such as fist-shaking (anger), crouching (sadness), and celebratory gestures (happiness), and found that older participants were less able to recognize these types of bodily expressions compared to a group of young controls. Previous studies investigating bodily emotion recognition among older adults have used stimuli that represent overt expressions of emotionality, such as fist shaking to denote anger (Ruffman et al. 2009a; Ruffman, Halberstadt & Murray 2009b; Ruffman et al, 2008). However, in naturalistic environments, emotions are not always overtly evident, especially when they are not directed towards another person, suggesting that these previous experimental paradigms may not be ecologically valid. This hypothesis is supported by a recent study suggesting that older participants do not always exhibit deficits when discriminating low intensity, negative facial expressions (Mienaltowski et al., 2013). Moreover, it is plausible that in these previous studies, participants were not extracting emotion information from the stimuli *per se*, but instead selecting responses on the basis of learned and familiar actions. As such, these previous findings may not specifically reflect age-related changes in the ability to extract emotion information from dynamic stimuli, but instead demonstrate the ability of older individuals to recognize expressions based on contextual cues. A further limitation of previous studies investigating age-related changes in emotion discrimination is the inclusion of several emotion labels on each trial. This methodological detail is important as the use of multiple emotion labels may produce age-related changes in performance that are not associated with actual perceptual deficits related to emotion discrimination (Mienaltowski et al., 2013; Phillips et al., 2008).

To address these issues, in the current study we used more subtle expressions of emotion and investigated whether older adults can recognize emotions conveyed by walking point-light displays that expressed happiness, sadness, and anger (Roether et al., 2009). These emotional walkers allow for a fine-grained parametric control of the shown emotion while ensuring that that the basic pattern of movement is similar for all stimuli. Therefore, the likelihood of having confounding effects from non-emotion specific mechanisms (e.g., different emotional gestures or ad-hoc expressions) is minimized.

There have been several studies that have used point-light walkers to investigate the effects of aging on biological motion. For example, studies have shown that older adults are impaired in detecting and discriminating point-light walkers in noise (Billino et al., 2008; Pilz et al., 2010) and discriminating actions from point-light displays (Norman et al., 2004; Insch et al, 2012). Moreover, point-light walker stimuli comprise both local and global motion cues: the trajectory of each dot constituting a point-light walker conveys information about the motion of a particular joint of the human figure (e.g., the ankles, the elbows, etc.), while grouping the motion of the local elements creates a holistic perception of the walker's global motion (e.g., whole body motion). Previous research suggests that both local (Mathers, Radford & West, 1992; Troje & Westhoff, 2006) and global information (Bertenthal & Pinto, 1994; Beintema & Lappe, 2002; Pilz, Bennett, & Sekuler, 2010) contribute to the perception of point light walkers. Aging may be associated with deficits in both local motion and global form processing. For example, several studies have identified age-related deficits in low-level local motion processing (Roudaia, Pilz, Sekuler & Bennett, 2009; Bennett, Sekuler & Sekuler, 2007; Snowden & Kavanagh, 2006), and others have indicated that older adults have difficulty grouping local elements into coherent global forms (Andersen & Ni, 2008; Del Viva & Agostini, 2007; Roudaia, Bennett & Sekuler, 2008).

Hence, older individuals may demonstrate impairment in the ability to discriminate biological motion due to age-related changes in both local motion and global form mechanisms. To investigate this question, Pilz et al. (2010) used normal, scrambled and random-position point-light walkers to investigate age-related changes in the perception of point-light walkers. Normal walkers contain both local and global form information, scrambled walkers contain preserved local motion information but disrupted global form (e.g., Bertenthal & Pinto, 1994; Troje & Westhoff, 2006), whereas random-position walkers contain preserved global form cues but substantially degrade local motion information (e.g., Beintema & Lappe, 2002). Although both younger and older participants performed at chance level for scrambled walkers, both age groups performed approximately equally, and well above chance, for upright and random position walkers. Additionally, Pilz et al. found that for inverted point light walkers, older adults performed worse with stimuli containing local motion information (i.e., normal walkers). Based on these results, Pilz et al. argued that, when discriminating less familiar stimuli such as inverted point-light walkers, older adults have difficulty integrating local motion and global form information as efficiently as younger adults, and furthermore rely more on global form than on local motion information. Recently, Insch et al., (2012) also investigated the relationship between the ability to discriminate actions and emotions from normal point-light walkers and local-global processing biases using a Navon task. Similar to Pilz et al. (2010), they found a decline in biological motion processing with age, which was significantly correlated with a local processing bias. However, differences in local-global processing did not fully account for differences in biological motion processing, perhaps because the stimuli and tasks used to assess local-global processing and biological motion differed on multiple dimensions.

The current study extends previous research by determining the extent to which older adults can recognize emotions conveyed by body motion, as opposed to overt actions linked to emotion, in point-light walkers. Furthermore, we broadened the examination of the relative roles of local and global motion information in emotion discrimination by using a single paradigm and task using normal, scrambled, random-position, and inverted walkers. The utilization of these varying point-light walker stimuli provides a method to study the contribution, and potential integration, of both local and global information. Lastly, the current study also examines other factors that may influence the ability of older adults to perceive biological motion that have not been addresses previously, including the importance of point-light walker stimulus duration and stimulus speed. The consideration of these parameters allows for a more thorough examination of emotion perception from point-light stimuli in healthy aging.

General Methodology

Participants

Each experiment consisted of 28-30 participants in both younger and older groups. Each participant took part in only one experiment (i.e., each experiment consisted of differing participant samples). In all experiments, younger and older participants had normal or correct-to-normal visual acuity and older participants were free of glaucoma, strabismus, amblyopia, macular degeneration, and cataracts, as confirmed by an optometrist or ophthalmologist within the three years prior to the experiments. Additionally, all participants completed a general health questionnaire, and no visual or general health problems were identified. All older participants also completed the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975) to assess general cognitive abilities; scores for all older participants were within normal range. There were no significant differences in age, visual acuity, and scores on the Mini-Mental State Examination (i.e., older adults) between the experimental groups. All participants were paid $10/hour for participation in the experiment.

Apparatus

All experiments were conducted on a MacIntosh G4 computer using MATLAB and the Psychophysics and Video ToolBox extensions (Brainard, 1997; Pelli, 1997; Kleiner et al., 2007). Stimuli were presented on a 19-inch monitor with a resolution of 1024 x 864 pixels and a refresh rate of 75 Hz.

Stimuli

The base emotional point-light walkers were developed by Roether et al. (2009), and a full description of their construction can be found there. Briefly, they were recorded with a Vicon 612 motion capture system (Vicon, Oxford, UK) consisting of eight cameras. Actors were recorded walking in a straight line with emotionally expressive gaits (happiness, sadness, anger). The actors were instructed not to make any emotional gestures. The resulting emotionally expressive point-light walkers consisted of 11 dots depicting the major joints of the body and the head. Walkers did not travel across the screen, but instead appeared to walk in place in a rightward (Experiments 1-3), or rightward and leftward (Experiment 4) direction. As described by Roether and colleagues (2009), perceptual experiments, including an emotion classification task, were conducted to ensure that the stimuli were easily recognizable among naïve observers. Findings from this task indicated that classification accuracy was high for all emotions, suggesting that the actors were able to produce emotions that were easily recognized. For the purpose of the current experiments, we used four different actors who produced three walking patterns for each emotion. Walker figures subtended 1.9 x 4.2 deg and stimuli duration ranged from 0.2 to 2.0 seconds, depending on the emotional walker that was used. The stimuli were presented in four, block-randomized conditions: upright, inverted, scrambled, and random-position. Inverted walkers were rotated by 180 deg so that they appeared to be walking on the ceiling. In the scrambled condition, the initial dot positions for the point-light walkers were presented at the correct x-position in the display, but with a randomly selected position along the y-axis of the display. The result was a point-light walker with intact local dot motion, but a distorted global form (e.g., Bertenthal & Pinto, 1994; Troje & Westhoff, 2006; Thornton et al., 1998; Pilz et al., 2010). For random-position walkers, the dots constituting the point-light walker on each frame were presented at random positions on the (invisible) skeleton of the walker between two adjacent joints (e.g., Beintema and Lappe, 2002; Pilz et al., 2010). In this condition, the global form of the walker was maintained, but the local dot motion was degraded. Additionally, the starting point of the stride cycle for each walker type was randomly chosen on every trial. This randomization procedure prevented participants from recognizing the stimulus from the starting position or from a specific frame.

Procedure

For all experiments, participants were seated in a darkened room and viewed the stimuli binocularly from a distance of 60 cm with their heads stabilized by a chin rest. On each trial of Experiments 1-3, the point-light walker's direction of motion was towards the right of the screen, and participants were asked to identify the emotion displayed by the walker by pressing a key on a standard QWERTY computer keyboard (i.e., space bar (happy), s key (sad) and l key (angry)). In Experiment 4, the walkers moved either leftward or rightward, and participants were asked to identify the direction of motion displayed by the walked by keyboard press (i.e., 'l' (rightward), and 'a' (leftward)). Prior to the experiment, participants performed four blocks of practice trials, each with five stimulus presentations, so that they were able to familiarize themselves with the stimuli and task.

Experiment 1

Methods

Twenty-eight younger participants (M = 23.5 years; thirteen male) and twenty-eight older participants (M = 68.7 years; sixteen male) took part in the experiment. Participants performed four blocks of trials, one for each walker type. The order of blocks was randomized across participants, and the presentation of the three emotions was randomized within each block. Each participant performed 60 trials for each emotion condition and walker type, resulting in 180 trials per block and a total of 720 trials. Walkers were presented at a frame rate of 25 frames per second, and were each shown for one full walk cycle (i.e., two steps). As a result, each emotion presented ranged from 0.2 to 2.0 seconds, depending on the natural speeds of the emotional walkers. Specifically, the mean duration times for the three emotions were as follows: 0.99 seconds for angry, 1.21 seconds for happy, and 1.93 seconds for sad point-light walkers.

Results

Figure 1 shows accuracy data for both age groups across all walker types and conditions. Arcsine-transformed accuracy data were analyzed with a 4 (walker type: upright, inverted, scrambled and random position) x 3 (emotion: happy, angry, sad) x 2 (age: older and younger) mixed design analysis of variance (ANOVA). We found a trending, although not significant, effect of age ($F(1,54) = 3.88$, $p = .061$, $\eta^2_G = .024$) indicating that, across all conditions, accuracy was slightly lower in older (77.7% correct) than younger (82.6% correct) participants[1]. We also found a main effect of walker type ($F(3, 162) = 105.57$, $p < .001$, $\eta^2_G = .189$): Participants performed most accurately on the upright condition (87.4% correct), followed by random position walkers (84.2% correct), inverted walkers (77.2% correct), and scrambled walkers (70.4% correct). Subsequent Bonferroni-corrected tests revealed that all pairwise comparisons between walker types were significant ($p < .0125$ in each case,

[1] This F test is a non-directional test. Given that previous studies reported that older adults generally are less accurate than younger adults in these types of tasks, a directional test, which would be significant at $p = 0.03$, would be more appropriate. Regardless of whether one adopts a directional or non-directional test to assess statistical significance, the current results suggest that the difference between older and younger participants was small (4.9% accuracy; Older participants 95% CI [75.5%, 79.8%]; Younger participants 95% CI [80.8%, 84.4%]) in the current conditions.

$d > 0.145$). Importantly, both groups of participants were able to discriminate emotion from the four walker types at levels significantly above chance (i.e., 33.3% accuracy; $p < .001$)

Insert Figure 1 about here

As illustrated in Figure 2, a main effect of emotion also was observed ($F(2, 108) = 33.87$, $p < .001$, $\eta^2_G = .160$): Accuracy was higher for happy (88.0% correct) and sad (79.4% correct) walkers than for angry walkers (72.5% correct). Subsequent Bonferroni-corrected tests revealed that all pairwise comparisons between emotions were significant ($p < .01$ in each case, $d > 0.344$). These main effects were accompanied by an interaction between walker type x emotion ($F(6, 324) = 8.09$, $p < .001$, $\eta^2_G = .030$). The interaction reflects the fact that identification accuracy was higher for sad than angry walkers in the normal and inverted conditions, but was about the same for those emotions in the scrambled and random conditions. None of the other interactions reached significance. Most importantly, we found no significant interaction between age group and walker emotions ($F(3, 162) = 0.06$ $p = .982$, $\eta^2_G < .001$).

Insert Figure 2 about here

Insert Table 2 about here

Discussion

Experiment 1 found that identification accuracy for emotions conveyed by point light walkers was slightly lower in older than younger participants, a difference that approached but did not reach conventional levels of statistical significance. Both younger and older participants were more accurate with upright walkers, followed by random-position, inverted, and scrambled walkers, though performance with all types of point-light walkers was observed to be above chance-level. Additionally, both younger and older participants were most accurate identifying happy point-light walkers compared to sad and angry walkers. Previous experiments examining the ability of older individuals to recognize emotions from faces and body stimuli have found that older adults discriminate negative emotions less accurately than younger individuals (Ruffman et al., 2008), but we found no evidence that the effect of walker emotion differed between age groups. Instead, both younger and older adults responded most accurately to happy, followed by sad and angry emotions.

Overall, both groups of participants were less able to identify emotions from point-light walkers in the scrambled and inverted conditions, suggesting that disrupting global form has a larger effect on the perception of emotion than disrupting local dot motion regardless of age. However, it is notable that accuracy in the scrambled condition (70.4% correct) was much higher than the near-chance accuracy reported in previous studies measuring direction discrimination with scrambled walkers (Pilz et al., 2010). This difference between accuracy in emotion and direction discrimination tasks may indicate that local motion cues convey more information about emotion than direction. However, it is also important to note that stimuli used by Pilz et al. (2010) were created with the Cutting-algorithm (Cutting, 1978) whereas those used in the present experiment were naturalistic, and stimuli based on the Cutting-algorithm may underestimate extent to which local motion cues are used (Saunders, Suchan, & Troje, 2009).

It is possible that the small age difference found in Experiment 1 can be explained by a general slowing of cognitive and motor functions (Salthouse, 1996). That is, older adults may require more time than younger adults to discriminate the actions or directions of point-light walkers (Norman et al., 2004; but also see Pilz et al., 2010, who showed that for certain conditions age-differences in biological motion perception persist over long stimulus durations). Therefore, it is possible that age differences found in the current experiment could have been eliminated by increasing the stimulus duration. Additionally, although the stimuli in Experiment 1 were equated for walk cycles, they were not equated for duration: Angry point-light walkers completed one walk-cycle in a shorter time compared to happy and sad walkers. As a result, it is possible that both younger and older participants utilized stimulus duration as a cue to identify emotions, rather than using the affective cues present in the stimuli. Furthermore, variation in duration time may have contributed to the decreased performance obtained with angry walkers, which were presented at shorter durations, compared to better performance observed for happy and sad walkers, which were presented at longer duration times. These hypotheses were evaluated in Experiment 2 by varying stimulus duration across a wider range.

Experiment 2

Methods

Thirty younger participants (M = 21.0 years, fifteen male) and thirty older participants (M = 71.3 years, sixteen males) took part in the experiment. The stimuli were similar to those used in Experiment 1. However, instead of presenting all walkers for one step cycle, the stimuli were displayed for stimulus durations of 5, 15, 30, and 45 frames at 25 fps, resulting in a total presentation time of 0.2, 0.6, 1.2 and 1.8 seconds, respectively. That is, resulting point-light walkers were looped, so that the resulting walkers were presented in the natural gait cycle for durations ranging from 0.2 to 1.8 s while walker speed was unchanged. Participants performed four blocks of trials, one with each walker type (i.e., normal, inverted, scrambled, and random), with the order of blocks randomized across participants. Between each block, participants were provided with a break, as needed, to prevent fatigue. Walker emotions and stimulus durations were randomized within each block. Participants were asked to identify the emotion displayed by the point-light walkers. Each participant completed 24 trials for each condition (4 durations x 4 walker types x 3 emotions), resulting in 288 trials per block for a total of 1152 trials. During practice trials, all participants were shown point-light walkers at stimulus duration of 1.8 seconds.

Results

Figure 3 shows response accuracy in each condition plotted as a function of stimulus duration. Accuracy generally was lower in older than younger participants, but the magnitude of the age difference varied considerably across conditions. A 4 (stimulus duration: 5, 15, 30 and 40 fps) x 4 (walker type: upright, inverted, scrambled and random position) x 3 (emotion: happy, angry, sad) x 2 (age: older and younger) mixed design ANOVA was performed on arcsine-transformed accuracy data. The key results of the ANOVA are listed in Table 2. The main effects of age, walker type, duration, and emotion were significant, as were the walker type x duration, emotion x duration, and walker type x emotion interactions. Significant three-way interactions -- age x emotion x duration, walker type x duration x emotion, age x walker type x duration -- were also significant. Finally, a significant age x walker type x duration x emotion interaction was also observed.

Insert Table 2 about here

The significant four-way interaction implies that age differences in response accuracy depended on walker type, walker emotion, and stimulus duration. Inspection of Figure 3 gives an indication of the source of the interaction: for sad walkers, age differences in accuracy were greatest at short durations and declined at longer durations; for happy walkers, age differences were nearly constant across durations; and for angry walkers, the age difference actually increased significantly at longer durations in the scrambled condition but was nearly constant for the other walker types. To evaluate these observations, the four-way interaction was analyzed by conducting separate age x duration x emotion ANOVAs within each walker type (corresponding to each row of panels in Figure 3). Within the upright point-light walker condition, a significant age x duration x emotion interaction was revealed ($F(6, 348) = 2.14$, $p = .04$, $\eta^2_G = .006$). We analyzed this three-way interaction by conducting separate group x duration ANOVAs for each emotion. For angry and happy emotions, the ANOVA revealed only a significant main effect of duration ($p < .001$, $\eta^2_G < .046$). Bonferroni-corrected pairwise comparisons indicated that accuracy improved as stimulus duration increased from 0.2 to 1.2 seconds ($p < .0125$, $d > .189$). However, no significant difference was observed between the 1.2 and 1.8 stimulus durations, suggesting that performance had reached an upper plateau. With sad walkers, the ANOVA revealed a significant group x duration interaction ($F(3, 174) = 7.70$, $p < .001$, $\eta^2_G = .057$), which reflected the fact that accuracy was significantly lower in older than younger participants only at stimulus durations of 0.2 and 0.6 seconds ($p < .05$, $\eta^2_G > .104$; Figure 3). In summary, with upright walkers the strongest evidence for an age difference in accuracy was obtained with sad walkers at the shortest durations.

Within the inverted point-light walker condition, a significant age x duration x emotion interaction was revealed ($F(6, 348) = 4.27$, $p < .001$, $\eta^2_G = .015$). Again, separate group x duration ANOVAs were conducted in each level of emotion. With sad walkers, the ANOVA revealed a significant age x duration interaction ($F(3, 174) = 4.99$, $p = .002$, $\eta^2_G = .032$): accuracy was lower in older participants at all durations, but the age difference was largest at short durations (Figure 3). Subsequent analysis showed that accuracy in younger participants increased as stimulus duration increased from 0.2 to 0.6 seconds and then was nearly constant at longer durations, whereas accuracy in older participants increased as duration increased from 0.2 to 1.2 seconds and then leveled off. With angry walkers we found a significant age x duration interaction ($F(3, 174) = 3.33$, $p = .021$, $\eta^2_G = .014$), which reflected the fact that the age difference in accuracy increased slightly as stimulus duration increased (Figure 3). With happy walkers we found a significant main effect of age ($F(1, 58) = 5.34$, $p = .024$, $\eta^2_G = .065$), indicating that accuracy was lower in older participants, and a significant main effect of duration ($F(3, 174) = 17.9$, $p < .001$, $\eta^2_G = .067$), indicating that accuracy increased at longer durations, but that age x duration interaction was not significant. In summary, with inverted walkers, we found that older adults performed less accurately than younger adults, and that the effect of stimulus duration on the size of the age difference differed across the three emotions.

Analysis of the scrambled point-light walker condition again revealed an age x duration x emotion interaction ($F(6, 348) = 7.71$, $p < .001$, $\eta^2_G = .044$), and therefore subsequent group x duration ANOVAs were conducted in each level of emotion. In the sad condition, the main effects of age ($F(1, 58) = 15.99$, $p < .001$, $\eta^2_G = .133$) and duration ($F(3, 174) = 221.82$, $p < .001$, $\eta^2_G = .629$) were significant, but the age x duration interaction was not ($F(3, 174) = 2.46$, $p = .064$, $\eta^2_G = .018$). Within the angry emotion condition, an age x duration interaction was observed ($F(3, 174) = 13.87$, $p < .001$, $\eta^2_G = .086$). Further analysis showed that both younger and older participants demonstrated similar levels of accuracy in both the 0.2 and 0.6 stimulus durations. In contrast, the emotion discrimination accuracy of younger participants significantly improved in the 1.2 and 1.8 stimulus durations, while older participants continued to demonstrate constant performance levels (Figure 4). In the happy condition, main effects of age ($F(1, 58) = 5.62$, $p = .021$, $\eta^2_G = .045$) and duration ($F(3, 174) = 25.23$, $p < .001$, $\eta^2_G = .183$) were found. Older participants showed reduced emotion discrimination accuracy overall and both groups demonstrated increased accuracy with longer stimulus durations.

Within the random position point-light walker, a significant age x duration x emotion interaction was revealed ($F(6, 348) = 3.96$, $p < .001$, $\eta^2_G = .014$) and subsequent group x duration ANOVAs were conducted in each level of emotion. In the angry and happy conditions, only a main effect of duration was observed ($F(3, 174) = 16.53$, $p < .001$, $\eta^2_G = .067$ and $F(3, 174) = 40.94$, $p < .001$, $\eta^2_G = .156$, respectively), in which performance improved with increasing stimulus duration and reached a plateau between 1.2 and 1.8 seconds. In the sad condition, a significant age x duration interaction was obtained ($F(3, 174) = 15.53$, $p < .001$, $\eta^2_G = .088$). Subsequent analysis indicated that both groups of participants showed increased accuracy between 0.2 and 0.6 seconds stimulus duration. However, the performance of younger participants remained constant, while older participants continued to demonstrate increased accuracy at 1.2 seconds stimulus duration (Figure 3). Lastly, it is important to note that both groups of participants were able to discriminate emotion from the four walker types at levels significantly above chance (i.e., 33.3% accuracy; $p < 0.001$, $d > 1.182$)

Insert Figure 3 about here

Discussion

Experiment 2 investigated whether age differences in emotion discrimination of point-light walkers depend on stimulus duration. We found that response accuracy generally was lower in older participants than younger participants, but the magnitude of the age difference depended on walker emotion, walker type, and stimulus duration. When discriminating happy point-light walkers, no apparent interactions between age and stimulus duration were observed among all walker types presented. These results suggest that although older participants are less able to recognize the emotion of happy compared to younger participants overall, both groups demonstrated similar abilities to extract relevant information pertaining to this emotion regardless of stimulus duration.

In contrast, when discriminating sad point-light walkers, the age-difference decreased with increasing stimulus duration, particularly for upright, inverted, and random walker types. More specifically, although older participants demonstrated poorer accuracy overall, significant age-differences with all walker types were observed only at the shortest stimulus durations times (e.g., 0.2, 0.6). These findings suggest that younger individuals extract the relevant local and global information pertaining to the emotion of sadness more efficiently and quickly than older adults.

For angry point-light walkers, the results were more variable. Only small, non-significant age-differences in accuracy were found with upright and random position point-light walkers, which suggests that the ability to identify anger on the basis of global form information is not affected by aging. Notably, no apparent interactions between age and stimulus duration were observed when discriminating anger from normal and random position point-light walkers. However, age differences in the inverted and scrambled conditions increased with stimulus duration: in those conditions, accuracy in younger participants, but not older participants, improved with increasing stimulus duration. These results suggest that older adults are less able to discriminate anger from stimuli that contain primarily local motion cues (i.e., scrambled walkers) and stimuli (i.e., inverted walkers) that are presented in a manner that interferes with global form processing (Pavlova & Sokolov, 2000; Troje &

Westhoff, 2006).

Experiment 2 demonstrates that stimulus duration differentially affects the perception of angry, happy, and sad walkers. Moreover, the fact that the effect of age depended on stimulus duration for all three emotions suggest that the age differences found in Experiments 1 and 2 were not simply due to older adults having insufficient time to observe the stimuli. Specifically, happy and emotion stimuli presented in Experiment 1 (i.e., 1.21 and 1.93 seconds for happy and sad point-light walkers respectively) were presented at sufficient stimulus durations in order to discriminate these emotions. Stimulus duration for angry point-light walkers in Experiment 1 (i.e., 0.99 seconds) was also sufficient for upright and random position point-light walkers. Moreover, results from Experiment 2 indicate that older adults were unable to discriminate cues pertaining to anger when using predominately local motion cues, regardless of stimulus duration.

Experiment 2 found age differences in the angry and sad emotion conditions. This result is consistent with studies that have suggested there is a specific age-related deficit in the recognition of negative emotions (Ruffman et al., 2008). Interestingly, when discriminating angry walkers, older participants, unlike younger participants, did not demonstrate improvement as stimulus duration increased. Instead, only younger participants benefitted from additional information in the longer displays. Moreover, these results were specific to the ability of older participants to extract emotion information related to anger from local, but not global cues.

In Experiment 2, point-light walkers were presented at varying durations to eliminate the confound between duration and emotion that existed in Experiment 1, but the speed of movement, or the velocity profiles, of the point-light walkers still varied across emotions. That is, because angry and happy walkers move at a quicker speed than sad walkers, participants may have discriminated the emotional walkers on the basis of speed information rather than emotion cues embedded within the point-light walkers. As a result, faster local motions may have biased participants to choose an angry or happy response, while slower stimuli may have resulted in the response of the sad emotion. To control for this factor, the velocity profiles of the point-light walkers used in Experiment 3 were equated.

Experiment 3

Methods

Thirty younger participants (M = 20.5 years, nine male) and thirty older participants (M = 69.5 years, twelve male) took part in this experiment. The stimuli were similar to those used in the previous experiments. To control for stimulus speed, the average distance travelled by the point-light walkers within a fixed period of time was equated for all emotions. This was done as follows: We computed the average stimulus duration for two step cycles per walker across all walkers (1.93 seconds for sad walkers, 0.99 seconds for angry walkers, and 1.21 seconds for happy walkers) and the average stimulus duration was calculated as 1.158 seconds. To equate, or normalize, the velocity profile across all walkers, dot speeds were adjusted so that all walkers completed two step-cycles in 1.158 seconds. As a result, angry and happy point-light walkers appeared to move slower than their original versions, whereas the sad walkers appeared to move faster. During the experiment, participants were asked to identify the emotion displayed by the point-light walkers. Each participant completed 180 trials for each block, resulting in a total of 720 trials. Prior to the start of the experiment, participants were familiarized with the emotional walkers for each walker type, during which walkers were also shown for 1.158 seconds.

Results

A 4(walker type) x 3(emotion) x 2(age) mixed design ANOVA was performed on arcsine-transformed accuracy data. The analysis revealed a significant main effect of age ($F(1,58) = 11.75$, $p = .001$, $\eta^2_G = .061$), where older participants performed worse than younger participants across all conditions. A main effect of walker type (F(3, 174) = 94.6, $p < .001$, $\eta^2_G = 0.232$) also was found: participants performed more accurately for upright walkers (80.7% correct) than random position (79.6% correct), inverted (66.0% correct), and scrambled walkers (60.0% correct). A main effect of emotion (F(2, 116) = 78.88 , p<.001, $\eta^2_G = .256$) was found, indicating that accuracy was higher for happy (82.7% correct) and sad walkers (72.6% correct) than for angry walkers (59.4% correct). These main effects were moderated by an interaction between age and emotion (F(2, 116) = 3.92, p=.023, η^2_G = 0.018): Older and younger participants performed similarly when the stimulus emotion was happy, but accuracy was significantly lower in older participants when the stimulus emotion was angry or sad (Figure 4). We also found an interaction between walker type and emotion (F(6, 342) = 7.34, $p < .001$, $\eta^2_G = 0.030$; Figure 5). Bonferroni corrected comparisons revealed that in the inverted condition, no significant differences were found between the emotions of happy and sad (p = .058). All other pairwise comparisons were significant. Lastly, it is important to note that both groups of participants were able to discriminate emotion from the four walker types at levels significantly above chance (i.e., 33.3% accuracy; $p < .001$, $d > 1.372$)

Insert Figures 4 and 5 about here

Discussion

Experiment 3 examined whether the removal of speed information from point-light walkers would alter the ability of participants to discriminate emotions from these stimuli. Similar to the previous experiments, emotion discrimination was, overall, less accurate in older participants compared to younger participants. However, using speed-equated walkers, we found that the age difference depended significantly on emotion: older participants were less accurate in identifying the negative emotions of sadness and anger compared to younger participants when confounding speed information was removed; however, no age difference for happy walkers was observed.

In Experiments 1 and 2, older participants demonstrated a reduced ability to discriminate negative emotions from point-light walkers, as would be predicted by results from previous studies investigation emotion recognition from facial and body information (Ruffman et al., 2008). Moreover, results from Experiment 3 were consistent with the idea that age might differentially affect the perception of positive versus negative emotions. One possible reason why older adults exhibited reduced accuracy on trials showing angry and sad point-light walkers in the current experiment is that the removal of speed information ensured that emotions were solely judged on emotion cues rather than stimulus speed. Interestingly, the removal of speed information affected older adults' performance only for negative emotions, which indicates that speed cues are less important for positive than negative emotions, and suggests that the ability to integrate local motion and global form information differentially affects the processing of positive and negative emotions. However, the underlying mechanisms need to be further investigated.

Similar to what was found in Experiments 1 and 2, performance in the scrambled walker condition was significantly above chance. These results differ from previous direction discrimination experiments using non-emotional scrambled walkers by Pilz et al. (2010), and therefore suggest that local motion cues provide more emotion-relevant information than directional information. However, as mentioned previously, the differential results could also be explained by the different stimulus types used in both studies. To investigate this issue directly, Experiment 4 measured performance in a direction discrimination task using our affective point-light walkers in the four walker type conditions.

Experiment 4

Methods

Participants

Thirty younger participants (M = 21.3 years, 10 male) and thirty older participants (M = 70.2 years, 14 male) took part in Experiment 4. The stimuli were similar to those used in Experiment 1, with the exception that the point-lighter walkers were presented as walking to the right or to the left. Participants performed four blocks of trials, one for each walker type, in which the order of blocks was randomized across all participants. Within each block, the three emotions were also presented randomly. Twenty-four trials were completed per condition, resulting in 288 trials in total. Walkers were presented at a frame rate of 25 frames per second, and were shown for one full walk cycle (i.e., 2 steps). As a result, the stimuli duration ranged from 0.2 to 2.0 seconds depending on the emotion condition. During the experiment, participants viewed the point-light walkers and judged the direction of motion of the stimuli (e.g., Right or Left). Prior to the experiment, participants completed five trials of each walker type, resulting in 20 practice trials.

Results

A 2(age) x 3(emotion) x 4(walker type) mixed design ANOVA was performed on arcsine-transformed accuracy data. We found a significant main effect of age ($F(1,58) = 26.31$, $p < .001$, $\eta^2_G = .124$), where older participants performed worse than younger participants across all conditions. A significant main effect of walker type ($F(3, 174) = 308.30$, $p < .001$, $\eta^2_G = .713$) also was found, as participants performed more accurately for upright (98.7% correct) and random position (98.6% correct) walkers compared to inverted (91.0% correct) and scrambled walkers (64.1% correct). A main effect of emotion ($F(2, 116) = 11.12$, $p < .001$, $\eta^2_G = 0.010$) was found: participants were better for happy (88.3% correct) and sad walkers (89.3% correct) than for angry walkers (86.7% correct). These main effects were moderated by an interaction between age and walker type ($F(3, 174) = 18.11$, $p < .001$, $\eta^2_G = .127$). Simple effects testing revealed that a significant difference between age groups was found only in the inverted condition ($F(1, 58) = 47.64$, $p < .001$, $\eta^2_G = .451$), although the group difference approached conventional levels of significance in the scrambled condition ($F(1, 58) = 3.68$, $p = .059$, $\eta^2_G = 0.060$; Figure 6). A significant walker type x emotion interaction was also revealed ($F(6, 348) = 4.28$, $p < .001$, $\eta^2_G = 0.012$): The simple main effect of emotion was significant only in the scrambled condition ($F(2, 118) = 10.29$, $p < .001$, $\eta^2_G = 0.055$), although it is important to note that this was the only condition in which a ceiling effect was not apparent. Bonferroni corrected comparisons (alpha = .05/3) revealed that, within the scrambled condition, accuracy in the angry condition was significantly different compared to the other emotion conditions ($p < .001$, $d > 0.429$; Figure 7). Lastly, it is important to note that both groups of participants were able to discriminate emotion from the four walker types at levels significantly above chance (i.e., 50.0% accuracy; $p < .001$; $d > 1.207$)

Insert Figures 6 and 7 about here

Discussion

Experiment 4 examined the ability of both younger and older participants to discriminate the walking direction of emotional point-light walkers. We found that older participants were, overall, less accurate than younger participants. Additionally, older participants had poorer accuracy in both the inverted and scrambled conditions compared to younger participants. Furthermore, in both age groups, direction discrimination with angry point-light walkers in the scrambled condition was less accurate compared to both sad and happy walkers.

As was found in Experiments 1-3, the results of the current experiment suggest that older individuals are less able to extract relevant information from local motion cues compared to younger participants. Additionally, as was found in Experiments 1-3, both older and younger participants were able to perform the discrimination task at above chance levels with scrambled stimuli. These results differ from those found by Pilz et al. (2010), in which younger and older participants performed at chance level when discriminating direction of motion from scrambled point-light walkers. It is important to note that Pilz et al. (2010) used stimuli that were generated from a Cutting algorithm (Cutting, 1978) that did not convey any emotional content, whereas those used in the current experiment were motion-captured walkers who were instructed to walk in a way that conveyed a particular emotion. In this context, although the results from Experiments 1-3 demonstrate that local motion may provide informative cues regarding affective information, the results from Experiment 4 suggest that the local motion of affective, naturalistic point-light walkers is more informative in general and provides both more affective and more directional information. It is interesting to note that within the scrambled walk type, both older and younger participants demonstrated reduced performance in discrimination direction using the angry stimuli. This result suggests that local cue information provided by the angry point-light walkers were less informative compared to happy and sad stimuli in direction discrimination more generally; however, as mentioned previously, it is important to consider that the other walker types, specifically the upright and random position point-light walkers, were noted to have ceiling effects. As such, it is possible that this ceiling effect may have masked the effect of emotion pertaining to these two walker types. The mechanisms that may underlie this effect are unknown and an avenue for future investigation; however, these results do suggest a relative poverty of directional information embedded with angry-related local motion trajectories. It is also important to note that although both groups of participants performed at above chance levels in all conditions in both the direction and affective discrimination tasks, performance was still relatively better in the emotion discrimination task, which had a chance performance level of 30%, compared to the chance performance level of 50% for the direction discrimination task.

General Discussion

The current experiments examined the ability of older participants to identify emotions from point-light walkers. Experiments 1-3 found that emotion discrimination accuracy generally was lower in older participants than younger participants, although the age differences depended on the emotion, stimulus speed, and stimulus duration. Also, both Experiments 2 and 3 demonstrated that in both age groups, accuracy was greater for happy walkers than for sad and angry walkers. Furthermore, in older adults this difference between happy and sad/angry walkers increased when speed was equated across all types of walkers in Experiment 3. Specifically, equating speed across the three emotions reduced older adults' response accuracy for angry and sad walkers. The larger age difference obtained with negative emotions is similar to the results obtained in previous studies that examined emotion recognition in older participants that utilized auditory stimuli (i.e., tone of voice) and other visual stimuli such as static faces or bodies (Ruffman et al., 2009a,b; Murray et al., 2010; Creighton et al., 2012). Lastly, the current study suggests that local motion may more generally provide informative cues regarding both affective information and directional information (Experiment 4), although older individuals were noted to have more difficulty using local cues compared to younger participants.

The disproportionally poorer performance for negative emotions found in older adults may reflect age differences in the way attention is allocated towards positive and negative stimuli. It has been suggested that older adults attend less to negative stimuli, or perhaps more to positive stimuli, compared to younger adults (Mather & Cartensen, 2005). Although both possibilities could lead to a larger age difference in response accuracy for negative emotions, some evidence suggests that it is more likely that older adults attend less to negative stimuli (Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Mather & Carstensen, 2003). For example, older participants tend to avoid looking at negative emotional faces compared to positive emotional faces. Also, some results suggest that age-related changes in frontal lobe function may also be related to changes in the ability to recognize specific emotions, such as anger (Adophs, 2002; Sprengelmeyer, Rausch, Eysel, & Przuntek, 1998). For example, Williams, Brown, Palmer et al. (2006) have shown a positive association with medial prefrontal activation and fear in older adults compared to younger individuals.

The current experiments utilized two negative emotions and one positive emotion, resulting in an imbalance in emotion valence. Due to this imbalance, it is at least plausible that participants performed the task by discriminating negative vs. position emotions, rather than actually classifying the three emotions. Examination of error-types in all four experiments found that the most common errors were between the happy and angry emotions, suggesting that participants were not discriminating negative and positive emotions *per se*, as this would have rather resulted in errors between angry and sad emotions. Notably, this pattern of errors is also consistent with findings from Roether et al (2009), from which the base emotional point-light walkers were developed. Hence, we believe that it is unlikely that participants were confusing the two negative emotions, although future research in this area may benefit from the utilization of balanced emotion valences. However, it is also important to note that both happy and angry point-light walkers contained more similar kinematic cues, such as larger (e.g., increased spatial displacement) and faster movement, compared to the sad point-light walkers (Roether et al., 2009). Consequently, it is possible that both younger and older observers were in fact confusing angry and happy stimuli due to these motion similarities rather than discriminating emotions *per se*.

Consistent with previous findings (e.g., Pilz et al., 2010), the results of this study demonstrate that both older and younger individuals are better able to utilize global form information, opposed to local motion cues, in the discrimination of emotions from point-light walkers. That is, both groups of participants demonstrated better performance when discriminating random positions walkers (i.e., stimuli containing only global structural information) specific to form, compared to scrambled point-light animations (i.e., stimuli containing only local motion cues). Moreover, similar to results obtained by Pilz and colleagues (2010), the results of Experiments 2 and 4 suggest that older individuals have more difficulty integrating local motion and global form information and rely more heavily on global form cues, perhaps because age-related changes in the visual system make it more difficult to accurately encode the trajectories of moving dots. For example, age-related neurophysiological changes in the visual system (e.g., V1, MT), including increased neural noise and decreased levels of inhibitory neurotransmitters have been observed in monkeys and cats (e.g., Hua et al., 2008; Leventhal et al., 2003), may make it more difficult to perceive low-level visual motion. Such neurophysiological changes, in addition to cognitive factors such as an age-related reduction in attention allocated towards negative emotions, may contribute to age differences in performance observed in the current study.

Unlike previous reports (e.g., Pilz et al., 2010), we found that participants were able to discriminate the direction of walking (Experiment 4) from scrambled local motion information alone (i.e., scrambled point-light walkers). One possible explanation for this finding is that local motion cues in the motion-captured emotional walkers used in the current experiments convey more directional information than the computer-generated Cutting-stimuli used by Pilz et al. (2010). It is also possible that the addition of affective information facilitated the ability of participants to discriminate direction information from local motion cues. The finding that local motion information provides affective information is related in some respects to results obtained in studies of agency and animacy. Heider and

Simmel (1944) showed that participants were able to impose human qualities such as emotion and intent to geometric shapes such as triangles and circles moving in certain ways within an aperture. The attribution of these properties to non-biological stimuli is a result of the qualities of motion, rather than the geometric characteristics of the stimuli (Szego & Rutherford, 2007; Szego & Rutherford 2008; Gergely et al., 1995; Kuhlmeier et al. 2003; Zacks, 2004). In a similar way, the local motion/motion trajectories of individual dots seem to convey information about emotional state even when global form information is disrupted, as it is the case for scrambled walkers, even if global form information typically dominates.

Similar to Roether et al (2009), results from Experiment 3, in which velocity profiles were equated across all emotions and walker types, suggest that velocity profiles of individual dots are not singly important for discriminating emotional walkers. That is, participants were still able to correctly identify the emotion of speed-matched walkers, although performance was generally worse than in the first two experiments in which both the local motion trajectories and velocity profiles were present within the stimuli. This result indicates that variation in walker speed may help observers to discriminate emotions, but that speed cues alone cannot account for our ability to discriminate emotions from point-light walkers.

In conclusion, our study demonstrates that the ability to discriminate emotions from point-light walkers decreases slightly with age. Our results are consistent with previous results regarding age-related difficulties discriminating emotions from point-light walkers. In addition, our results show that age differences are slightly larger for negative emotions such as anger and sadness even when those emotions are conveyed by changes in gait, as opposed to overt expression of emotion used in previous studies. Interestingly, both older and younger participants were able to discriminate walker emotion and direction based on local motion information alone, supporting the view that local motion cues alone provide sufficient information to perceive certain aspects of biological motion.

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Table 1. Mean accuracy values across all experiments. Note that Experiments 1-3 are emotion discrimination tasks, while Experiment 4 is a direction discrimination task.

	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Age				
Young	0.826	0.763	0.763	0.913
Old	0.777	0.666	0.667	0.849
Walker Type				
Upright	0.874	0.807	0.807	0.987
Inverted	0.772	0.669	0.660	0.910
Scrambled	0.704	0.589	0.599	0.641
Random Position	0.849	0.793	0.796	0.986
Emotion				
Angry	0.725	0.660	0.594	0.868
Happy	0.880	0.784	0.827	0.883
Sad	0.794	0.699	0.726	0.893

Table 2. ANOVA on arcsine-transformed accuracy values from Experiment 2.

Factor	*F*	*p*-value	η^2_G
Age*	$F(1,58) = 17.22$	$p < .001$	.063
Walker Type*	$F(3, 174) = 177.09$	$p < .001$	0.213
Duration*	$F(3, 174) = 390.19$	$p < .001$	0.188
Emotion*	$F(2, 116) = 22.81$	$p < .001$	0.082
Walker Type x Duration*	$F(9, 522) = 5.10$	$p < .001$	0.004
Duration x Emotion*	$F(6, 348) = 6.24$	$p < .001$	0.053
Age x Walker Type	$F(3, 174) = 0.53$	$p = .661$	< .001
Age x Emotion	$F(2, 116) = 1.28$	$p = .281$	0.005
Walker Type x Emotion*	$F(6, 348) = 6.24$	$p < .001$	0.016
Age x Emotion x Duration*	$F(6, 348) = 9.39$	$p < .001$	0.013
Walker Type x Emotion x Duration*	$F(18, 1044) = 4.50$	$p < .001$	0.011
Age x Walker Type x Duration*	$F(9, 522) = 6.39$	$p < .001$	0.005
Age x Walker Type x Duration x Emotion*	$F(18, 1044) = 2.33$	$p = .001$	0.006

Figure Captions

Figure 1. Response accuracy from Experiment 1. All participants showed reduced accuracy in the scrambled and inverted conditions compared to upright and random position conditions. Older participants also showed a trend in reduced accuracy overall across all conditions. No interaction between age and walker type were revealed. Error bars represent ± 1 SEM.

Figure 2. Response accuracy of walker types and emotion conditions from Experiment 1. In the scrambled and random position walker type conditions, no significant differences were observed between the discrimination of angry and sad emotions.

Figure 3. Response accuracy for all walker types across all emotion conditions from Experiment 2.

Figure 4. Response accuracy from Experiment 3, highlighting the age x emotion interaction. With speed-matched point-light walkers, older participants were significantly worse when discriminating negative emotions (angry and sad) compared to the positive emotions (happy).

Figure 5. Response accuracy from Experiment 3, highlighting the walker type x emotion interaction. Using speed-matched point-light walkers, no differences were observed across all participants in the happy and sad conditions in the inverted walker type. In the scrambled conditions, no differences were observed between the angry and sad conditions across all participants.

Figure 6. Response accuracy from Experiment 4. Older participants showed significantly decreased accuracy when discriminating the direction from inverted point-light walkers. Older participants also showed decreased performance in the scrambled walker type conditions, although this was approaching significance.

Figure 7. Response accuracy for Experiment 4. Significant differences in emotion discrimination were

only found in the scrambled walker type condition, where angry showed decreased performance compared to the other emotion condition.

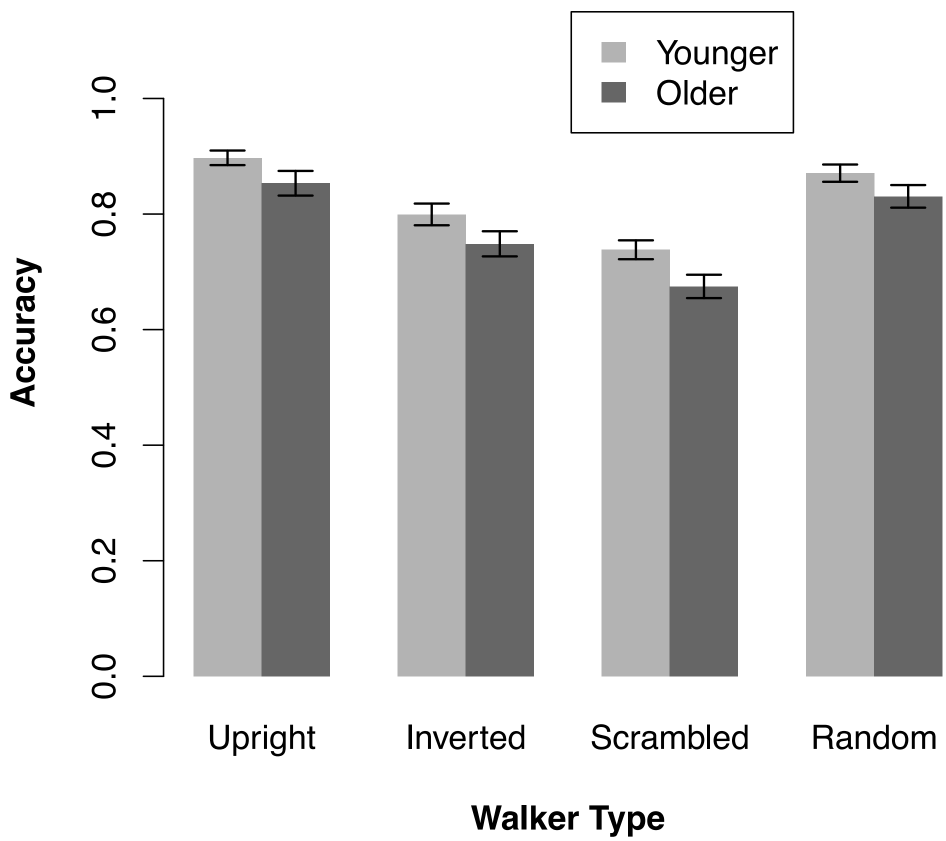
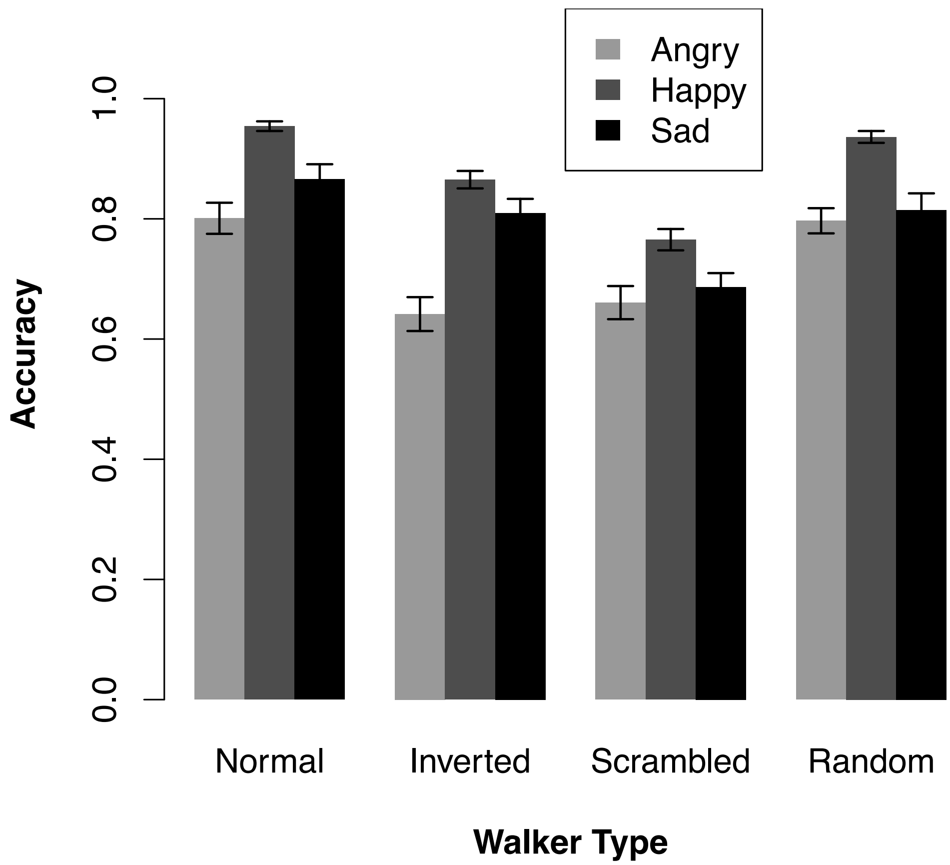
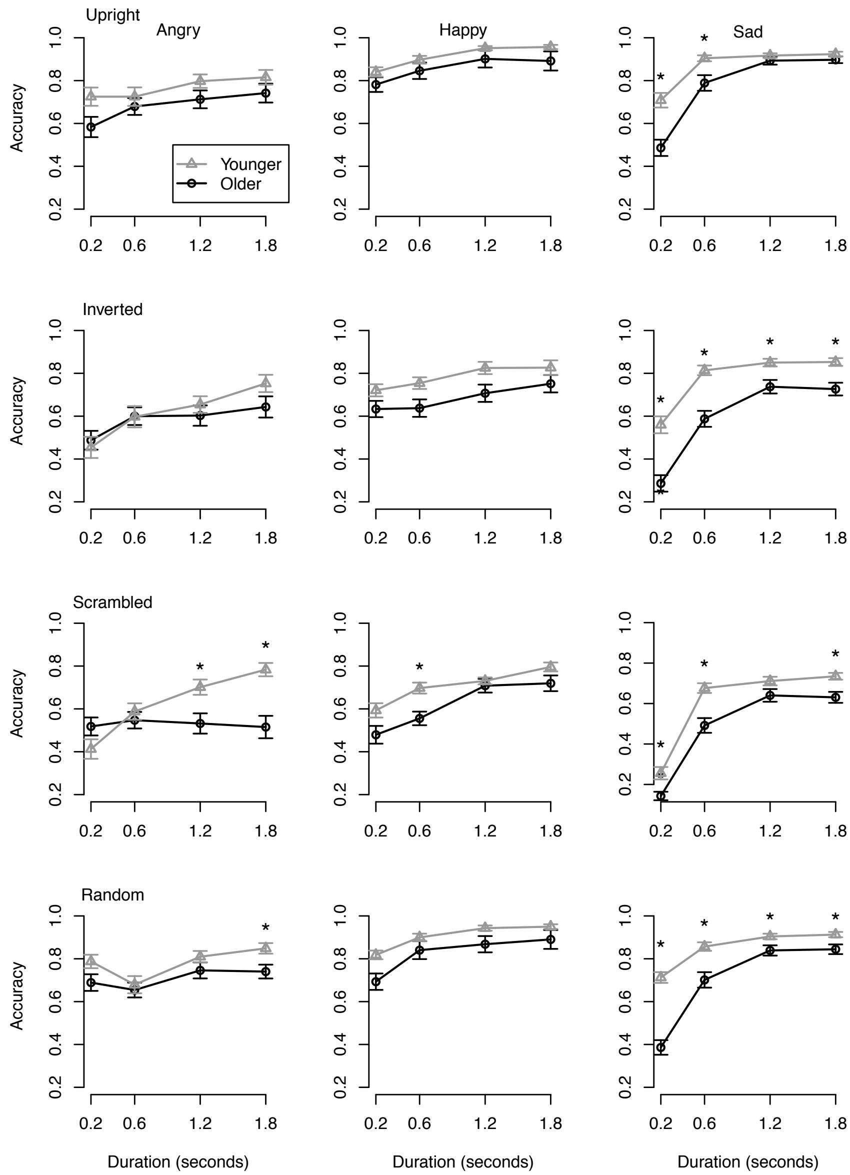

Younger
Older
Accuracy
0.0
0.2
0.4
0.6
0.8
1.0
Upright
Inverted
Scrambled
Random
Walker Type

Figure 1.



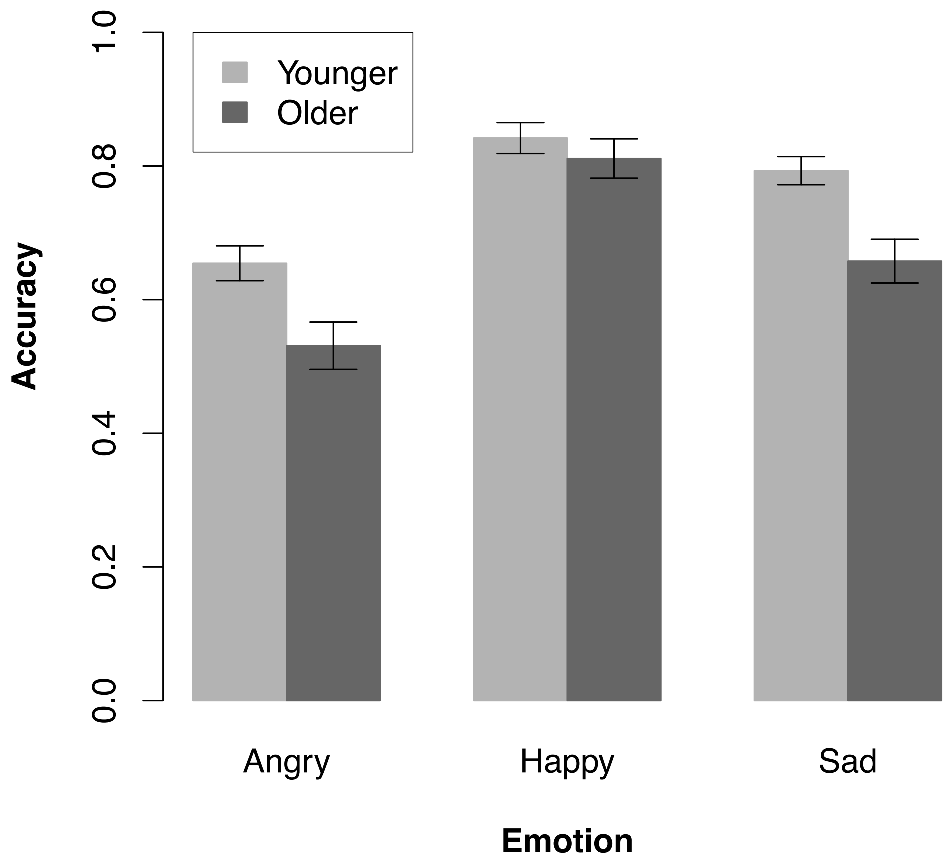
Angry
Happy
Sad
1.0
0.8
0.6
0.4
0.2
0.0
Accuracy
Normal
Inverted
Scrambled
Random
Walker Type

Figure 2.



Upright
Angry
Happy
Sad
Younger
Older
Inverted
Scrambled
Random
Accuracy
Duration (seconds)

Figure 3.



Younger
Older
Accuracy
0.0
0.2
0.4
0.6
0.8
1.0
Angry
Happy
Sad
Emotion

Figure 4.

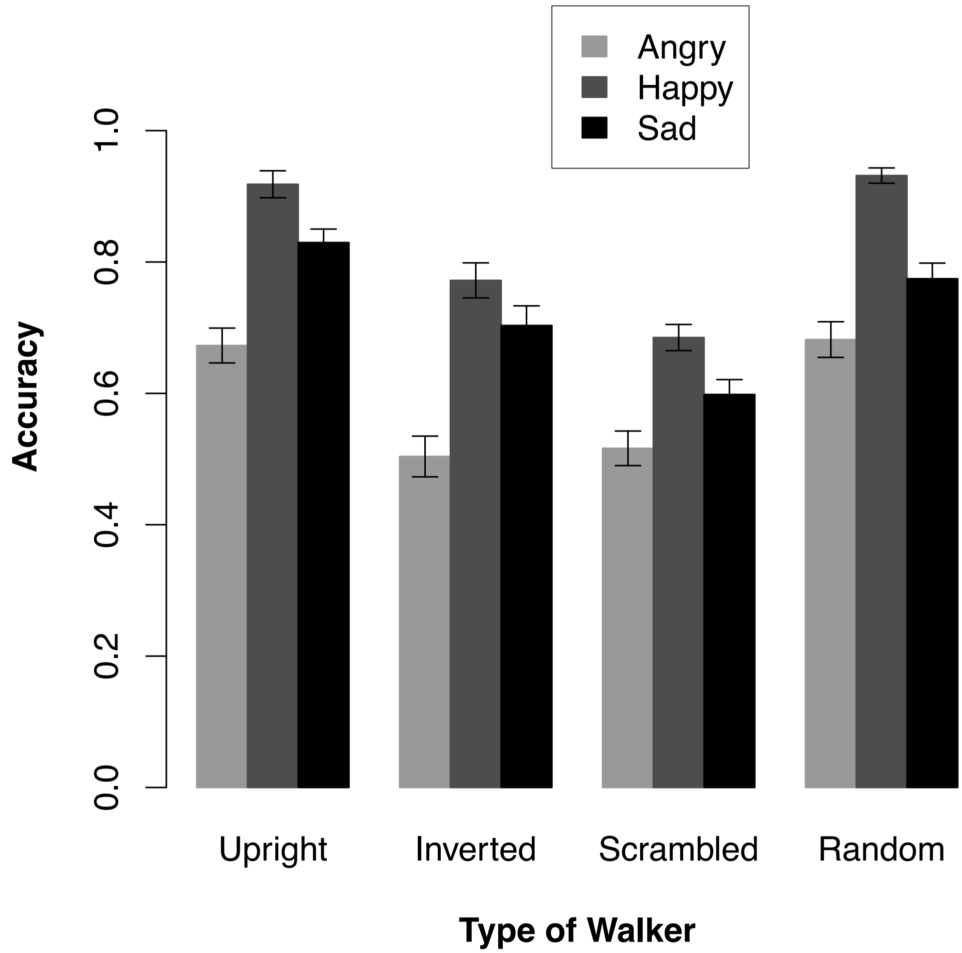

Angry
Happy
Sad
Accuracy
0.0
0.2
0.4
0.6
0.8
1.0
Upright
Inverted
Scrambled
Random
Type of Walker

Figure 5.

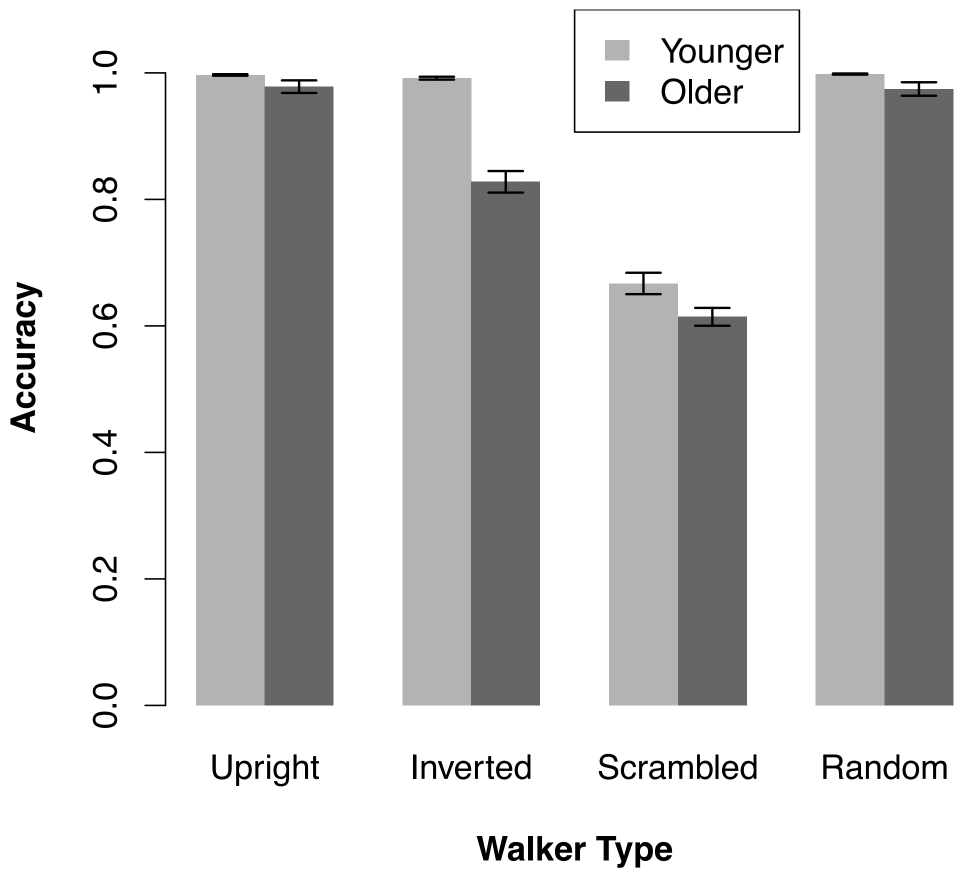

Younger
Older
Accuracy
0.0
0.2
0.4
0.6
0.8
1.0
Upright
Inverted
Scrambled
Random
Walker Type

Figure 6.

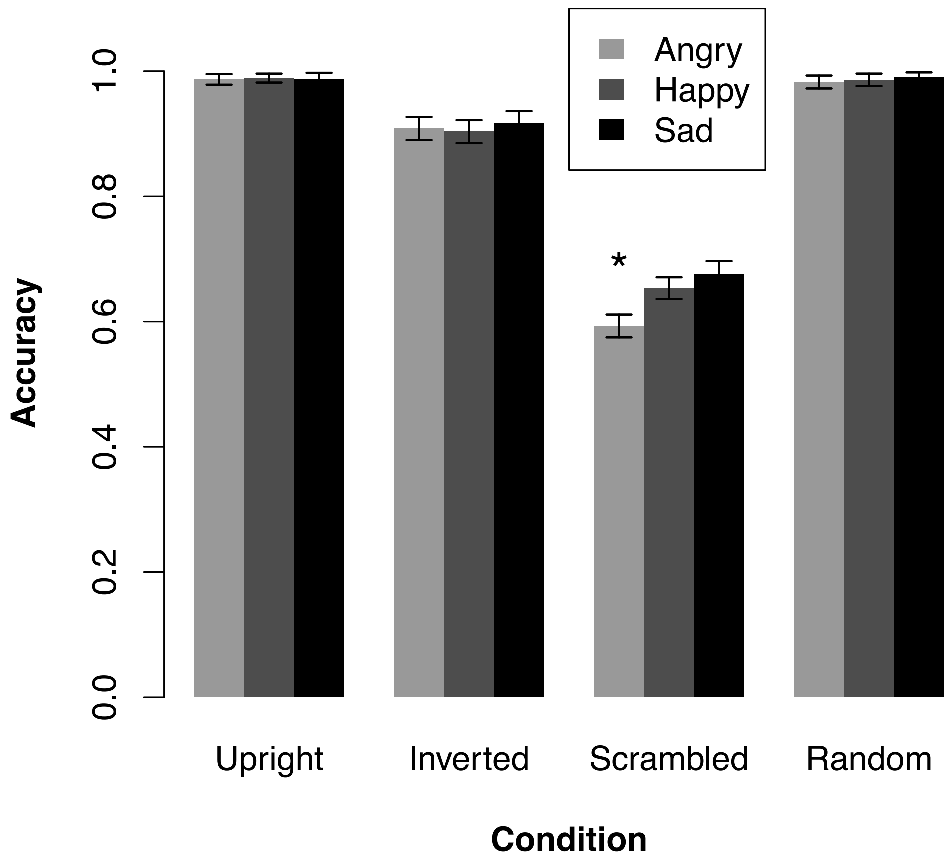

Angry
Happy
Sad
Accuracy
1.0
0.8
0.6
0.4
0.2
0.0
*
Upright
Inverted
Scrambled
Random
Condition

Figure 7.