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Atypical Emotion Recognition From Bodies Is Associated With Perceptual Difficulties in Healthy Aging

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A range of processes are required for recognizing others' affective states. It is particularly important that we process the perceptual cues providing information about these states. These experiments tested the hypothesis that difficulties with affective state identification in older adults (OAs) arise, at least partly, from deficits in perceptual processing. To this end we presented "point light display" whole body stimuli to healthy OAs and comparison younger adults (YAs) in 3 signal detection experiments. We examined the ability of OAs to recognize visual bodily information—posture and kinematics—and whether impaired recognition of affective states can be explained by deficits in processing these cues. OAs exhibited reduced sensitivity to postural cues (Experiment 1) but not to kinematic cues (Experiment 2) in affectively neutral stimuli. Importantly, they also exhibited reduced sensitivity only to affective states conveyed predominantly through posture (Experiment 3) —that is, the cue they were impaired in perceiving. These findings highlight how affective state identification difficulties in OAs may arise from problems in perceptual processing and demonstrate more widely how it is essential to consider the contribution of perceptual processes to emotion recognition.

Public Significance Statement

This study demonstrates that perceptual impairments in healthy aging contribute to difficulties recognizing others' emotional state from the way that they move. For instance, if older adults cannot perceive accurately that another's limbs are relaxed, they cannot use this information to determine that they are feeling happy rather than tense. These findings highlight how it is essential to consider the contribution of perceptual processes when theorizing about emotion recognition, both in healthy aging and other populations.

Keywords: emotion recognition, vision, body perception, healthy aging

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A range of processes are required for recognizing the affective states of others (Happé, Cook, & Bird, 2017), many of which are directly involved in identifying that a certain hidden "internal" state (e.g., anger) was the driving force behind another individual's observed behavior. However, it is also particularly important that we process the perceptual cues providing information about these states. A variety of cues provide this information, including the lexical content and intonation of our speech, our facial expressions and our body language—both our posture and the kinematics of our movements. For example, perception of relaxed limbs can signal happiness, while perception of fast, jerky movements can signal anger (Dael, Mortillaro, & Scherer, 2012; Montepare, Koff, Zaitchik, & Albert, 1999; Wallbott, 1998). If we are insensitive to a certain perceptual cue (e.g., relaxed limbs in another) we will be

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unable to use this information to determine another's internal state, and to use this state attribution for effective social understanding and communication.

Older adults (OAs) exhibit impairments in recognizing affective states from facial expressions (Calder et al., 2003; Keightley, Winocur, Burianova, Hongwanishkul, & Grady 2006; Kessels, Montagne, Hendriks, Perrett, & de Haan, 2014; MacPherson, Phillips, & Delia Sala, 2006) and whole-body movements (Montepare et al., 1999; Ruffman, Sullivan, & Dittrich, 2009; Spencer, Sekuler, Bennett, Giese, & Pilz, 2016), which are thought to result in a cascade of problems in social understanding and communication and hence exacerbate social difficulties associated with isolation (Happé, Winner, & Brownell, 1998; Luo, Hawkley, Waite, & Cacioppo, 2012; Shankar, McMunn, Banks, & Steptoe, 2011). These difficulties with emotion recognition are hypothesized (e.g., Ruffman, Henry, Livingstone, & Phillips, 2008; Sullivan & Ruffman, 2004) to arise from neurophysiological changes in the "social brain"—involving regions such as the orbitofrontal cortex, cingulate cortex and amygdala—that is, the network implicated in the "accurate perception of the dispositions and intentions of other individuals" (p. 367; Brothers, 2002). It appears to follow from this account (e.g., Ruffman et al., 2008) that problems with social cognition are caused directly by problems in post-perceptual mechanisms for computing internal states.

However, at least some of the age-related deficits in emotion recognition may result not from post-perceptual processes but from changes in perceptual processing. Alongside anatomical changes that influence perceptual processing—such as a decline in the senescent optics of the eye (Elliott et al., 2009), thinning of retinal nerve fiber (Parikh et al., 2007) and cortical changes in visual regions (Brewer & Barton, 2014)—aging is associated also with more cognitive perceptual changes such as difficulties with "configural" sensory processing, requiring integration across "local-level" features. For instance, OAs exhibit smaller "global precedence" effects, such that the speed advantage typically observed in recognizing the global form of objects in comparison with local features is reduced in OAs (e.g., Insch, Bull, Phillips, Allen, & Slessor, 2012; Lux, Marshall, Thimm, & Fink, 2008; Oken, Kishiyama, Kaye, & Jones, 1999; Slavin, Mattingley, Bradshaw, & Storey, 2002).

The present experiments examined the ability of OAs to recognize visual information that is critical for emotion recognition from body movements—specifically posture and kinematics—and whether impaired recognition of affective states can be explained, at least partly, by deficits in processing these cues. We used a signal detection paradigm, allowing dissociation of signal sensitivity from response biases (Kingdom & Prins, 2010), in contrast with previous studies of emotion recognition in OAs which have typically used accuracy measures. All experiments presented point light displays (PLDs) where major joints of the human body are represented by a point of light against a uniform background (Johansson, 1973). These displays are widely used in the study of body perception because they allow presentation of kinematic and postural information while removing other cues such as facial expressions.

Experiment 1 required participants to detect a postural feature of the stimuli, and Experiment 2 a kinematic feature. Experiment 3 required detection of affective states, presenting affective states that have been found to rely differentially on postural and kinematic information. We predicted that OAs would predominantly exhibit deficits in detecting those affective states conveyed through cues they were impaired in perceiving, which would suggest that impairments in perceptual processes may account, at least partly, for atypicalities in emotion recognition.

Experiment 1

Experiment 1 required participants to detect a postural feature of the PLD walker. They were asked to report whether one arm (e.g., right) of the walker was flexed at a more acute angle at the elbow than the other (e.g., left). To do so, participants needed to assess the position of the dot representing the wrist on one side of the body relative to those representing other body parts—particularly the elbow and shoulder on the same side, and the equivalent body parts on the other side of the body. We presented "Postural Difference" trials, where the described difference was present and "No Postural Difference" trials where it was not (i.e., both elbows were equally flexed). Although the PLDs were in motion in Experiment 1, the manipulation did not affect other aspects of implied movement so, for example, walking speed was the same for Postural Difference and No Postural Difference trials.

Across all experiments, sensitivity to probed stimuli was calculated as d', which indicates the extent to which participants are more likely to report the presence of a probed stimulus when it is present than when it is absent, that is, the difference between the z-scores of the hit rate (HR; proportion of Postural Difference trials correctly identified) and false alarm rate (FAR; proportion of No Postural Difference trials wrongly identified as Postural Difference trials; $d' = \theta^{-1}(HR) - \theta^{-1}(FAR)$; p. 153; Kingdom & Prins, 2010). We report results in relation to sensitivity below (response bias findings are presented in online supplementary materials).

Method and Participants

Two groups participated in Experiment 1, 30 YAs aged 35 or under ($M = 27.5$, $SD = 4.7$, 21 females) and 27 OAs aged 60 or older ($M = 73.5$, $SD = 7.5$, 17 females). One OA was excluded from analysis due to a large negative d', making the participant a statistical outlier and indicating confusion over task demands. The sample size was determined in all experiments reported in this article such that we would have at least 80% power to detect a medium-sized group x condition interaction effect ($\eta_p^2 = 0.06$, $\alpha = .05$), in line with previous studies of emotion recognition (Ruffman et al., 2008; the number of participants undertaking all three experiments was also past this threshold). This requirement led to the calculation that we would require at least 24 in each group to detect effects. Note that in all experiments we report more than 24 in each group because we tested all who responded to our recruitment drive within a specified time-frame.

In Experiment 1, as in all experiments reported in this paper, participants had normal or corrected-to-normal vision according to self-report. The experiments were carried out in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and approved by the Birkbeck, University of London Ethics Committee.

We obtained Weschler Abbreviated Scale of Intelligence (WASI) scores for two subtests (matrix reasoning and vocabulary) for 26 OAs and 28 YAs in Experiment 1. Raw OA scores ($M = 70.5$, $SD = 7.1$; FSIQ2 equivalent = 128.3) did not differ significantly from raw YA scores ($M = 71.9$, $SD = 5.4$, FSIQ2 equivalent $= 122.7$[1]): $t(52) = 0.84$, $p = .41$.

Stimuli. In Experiment 1, and in other experiments reported in this paper, stimuli were PLD videos adapted from those developed by Nackaerts et al. (2012; see also Edey, Yon, Cook, Dumontheil, & Press, 2017). Experiment 1 used PLD videos of two actors (one male, one female) in affectively neutral states shown from two different viewpoints (coronal [0°] or intermediate to coronal and sagittal [45°]) and played at a rate of 40 frames per second (mean velocity = 3.91 pixels/frame [$SD = 1.69$]; mean acceleration = 1.30 pixels/frame^2 [$SD = .21$]). All videos in Experiment 1 were 2-second clips and, in No Postural Difference trials, the angle of flexion at the elbow was equivalent for right and left arms.

Postural Difference trials adapted the videos such that the average angle of flexion at the elbow of one arm was greater than the other arm. For each frame of each video, the angle was calculated between the elbow and wrist, and elbow and shoulder. Coordinates for a revised wrist position were then established based on rotating its position relative to the elbow by a proportion of the original angle. This manipulation maintained the appearance of a natural arm swing in that the precise angles of flexion at both elbows varied systematically across the video, but generated a more acute angle between the points representing the wrist, elbow, and shoulder in one arm than the other. Figure 1 illustrates the difference between Postural Difference and No Postural Difference trials by giving three equivalent example frames from Experiment 1 (see also Supplementary Videos). Two versions of each Postural Difference video were produced, differing in the extent of arm flexion and therefore signal strength. Small signal videos reduced the apparent angle between the shoulder, elbow and wrist by 10%, and large signal videos by 15%, over the course of the video.

This combination of two actors, two viewing angles, left and right arm flexion versions, and large and small postural signals, generated 16 Postural Difference videos. There were four No Postural Difference videos, corresponding to the two actors and two viewing angles.

Procedure. In Experiment 1, and all other experiments reported in this paper, participants were seated in a dimly lit room at an approximate distance of 40 cm from a 24 in. LCD computer monitor (resolution = 1920 × 1200 pixels; refresh rate = 60 Hz). The experiments were conducted in MATLAB® using the Cogent graphics toolbox.

On each trial, participants were shown a PLD video and then asked either “Was the arm on the right of the screen more bent?” or “Was the arm on the left of the screen more bent?” Participants did not know which of the two questions they would be asked during the stimulus presentation. Participants responded “yes” or “no” using left and right keys, respectively. Participants were shown their answer and prompted to change their response or press a key to continue. Participants saw no videos containing a signal other than the probed target signal, for example, where the arm on the right was flexed to a greater extent but the left arm was probed.

Trials were presented to each participant in two blocks of 56. Within each block, each Postural Difference video was presented twice, and each No Postural Difference video was presented six times, resulting in 32 Postural Difference trials and 24 No Postural Difference trials (see online supplementary materials for a discussion of methodological decisions with respect to trial numbers). Presentation order was fully randomized within each block.

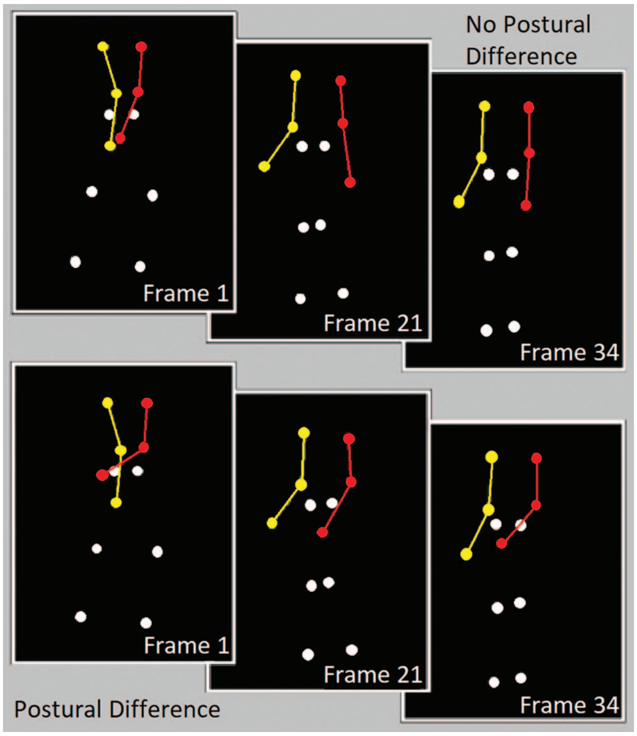

Figure 1. Example frames from videos used in Experiment 1 (frames 1, 21, and 34) in the No Postural Difference (top) and Postural Difference (bottom) conditions. Color and lines are used to highlight the arm position at equivalent frames; in the Postural Difference stimulus the red (shaded) arm on the right of the image is flexed at a more acute angle than the yellow (unshaded) arm on average across the video. In the actual videos, all PLDs were white on black, without connecting lines. The question presented in this example was “Was the arm on the right of the screen more bent?” See the online article for the color version of this figure.

Results and Discussion

One sample t tests confirmed that d' was significantly positive for both YAs ($M = 0.87$, $SD = 0.45$; $t[29] = 10.58$, $p < .001$) and OAs ($M = 0.62$, $SD = 0.32$; $t[26] = 10.07$, $p < .001$) indicating that both groups were able to distinguish Postural Difference from No Postural Difference trials. We conducted a mixed ANOVA on the d' data with size of the postural signal (large or small based on the extent of implied arm flexion) as a within-participants factor, and age group as a between-participants factor (see online supplementary materials for tables of descriptive and inferential data; the findings in all three experiments did not interact with the block or the question asked so analyses are reported collapsed across these factors). Unsurprisingly, there was a main effect of size of the postural signal, confirming that the signal was harder to detect when the extent of implied arm flexion was lower ($F[1, 55] = 44.10$, $p < .001$, $\eta_p^2 = 0.45$). Importantly, there was also a main effect of age group, with YAs more sensitive to differences in

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[1] Raw scores provide a more appropriate comparison in the present context of comparing between age groups because FSIQ2 scores are normalized by age group, marginally increasing the score for the older participants.

posture than OAs ($F[1, 55] = 6.30$, $p = .01$, $\eta_p^2 = 0.10$; see Figure 2A). There was no interaction between the size of postural signal and age group, $F(1, 55) = 1.86$, $p = .18$.

These findings therefore demonstrated that OAs were less sensitive than YAs to postural body features.

Experiment 2

The findings from Experiment 1 demonstrate that OAs exhibited lower sensitivity to postural body features. Reduced performance in Experiment 1 is unlikely to be due to a decline in intellectual capabilities (Salthouse, 2005; Salthouse, 2012) – WASI scores were matched between OAs and YAs and the OA impairment was numerically smaller in the more demanding version of the experimental task (see Figure 2). However, as already noted, OAs exhibit reduced functioning in several aspects of visual processing and it is important to ascertain the specificity of the effect, especially given that the visual acuity was assessed simply according to self-report. We therefore designed Experiment 2 such that task demands were broadly similar to Experiment 1, but participants were required to detect whether the velocity of the walker in the PLD increased or decreased across the time-course of the video. Participants thereby identified a kinematic feature of the stimuli, rather than a postural feature.

Method and Participants

Two groups participated in Experiment 2, 39 YAs aged 35 or under ($M = 27.5$, $SD = 4.7$ years, 26 females) and 39 OAs aged 60 or older ($M = 70.7$, $SD = 6.9$ years, 26 females).

We obtained WASI scores for 27 OAs and 28 YAs in Experiment 2. Raw OA scores ($M = 70.4$, $SD = 6.9$; FSIQ2 equivalent = 128.0) did not differ significantly from raw YA scores ($M = 71.5$, $SD = 4.9$, FSIQ2 equivalent = 122.3; $t[53] = 0.67$, $p = .50$).

Stimuli. No Kinematic Difference trials presented unadapted videos identical to those presented as No Postural Difference trials in Experiment 1. In Kinematic Difference trials the same PLD videos were manipulated so that the velocity of the PLD figure

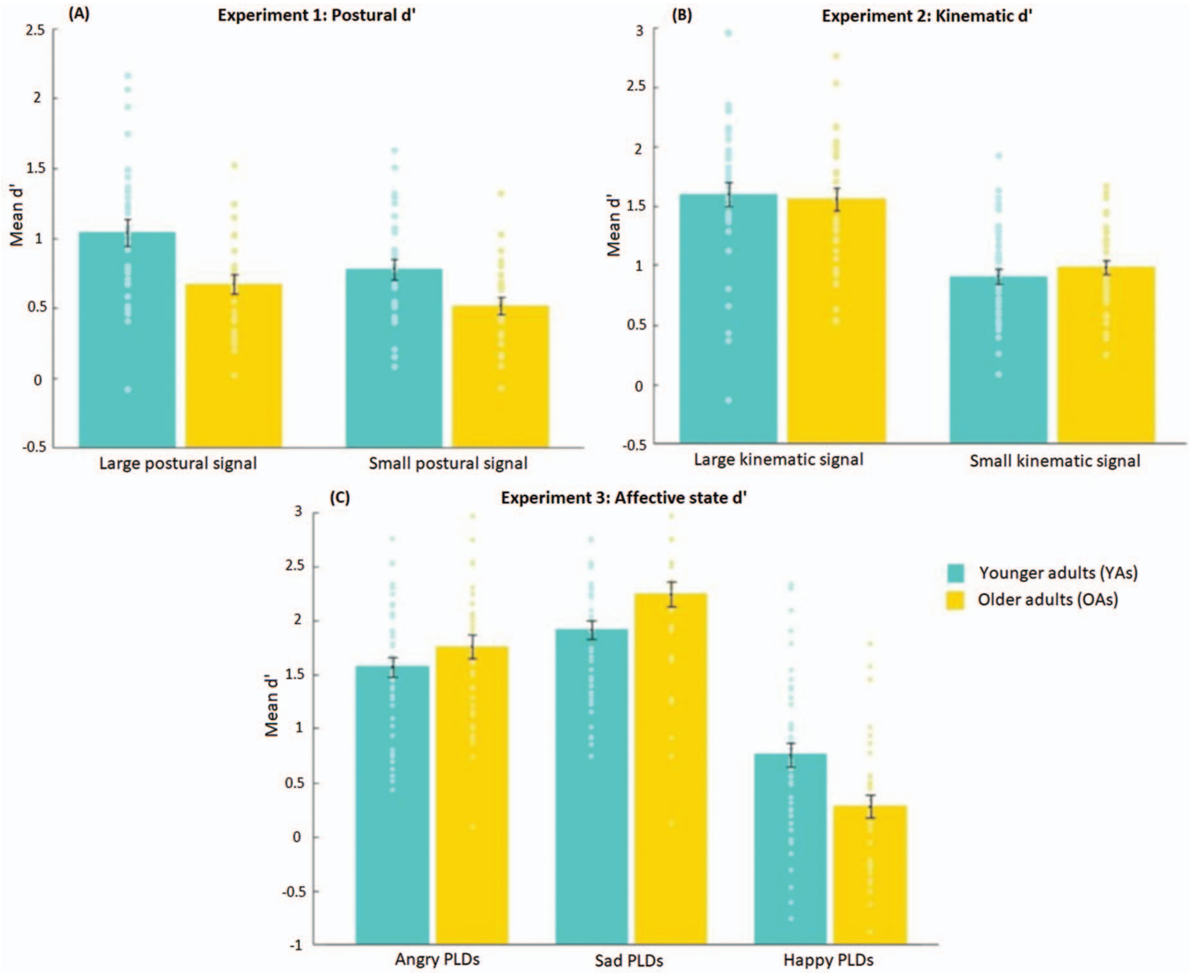

Figure 2. Mean sensitivity (d') in YAs and OAs in the three experiments. Error bars represent ± 1 *SE* of the mean and individual points represent performance for each participant. (A) Experiment 1. Sensitivity to postural signal. (B) Experiment 2. Sensitivity to kinematic signal. (C) Experiment 3. Sensitivity to anger, sadness and happiness. See the online article for the color version of this figure.

either steadily increased or decreased during the second half of the video, while leaving posture unchanged. To generate the appearance of a gradual change in velocity, the coordinates of each point in each frame in the second half were recalculated according to a power function such that they appeared increasingly ahead of (or behind) the original while remaining on the same trajectory (see Supplementary Videos; also note that it has been suggested that acceleration cannot be directly detected over short time periods [Brouwer, Brenner, & Smeets, 2002] and therefore participants may in fact use velocity information as the basis for discriminations, but our hypotheses do not rest on which of these features are used by participants). The velocity change function was in the form $w = x + y^a(z)$ where x is the original position of a point in frame number y, z the change in position between frames y and y + 1, and a, the power constant. Altering “a” makes the change more or less extreme. Two versions of each Kinematic Difference video were produced, differing in the size of kinematic signal based on degree of change in velocity. Small signal videos presented implied velocities at the end of the video that differed from the first half by 30%, and large signal videos by 50%, with the rate of change in velocity constant across the second half. The combination of two actors, two viewing angles, videos where velocity increased and decreased, and large and small kinematic signals, generated 16 Kinematic Difference videos. As in Experiment 1, all videos were of 2 seconds duration.

Procedure. The procedure matched Experiment 1, except that participants were asked either “Was the person speeding up?” or “Was the person slowing down?” As in Experiment 1, trials were presented to each participant in two blocks of 56 and presentation order was randomized within each block.

Results and Discussion

One sample *t* tests confirmed that sensitivity (d') was significantly positive for both YAs ($M = 1.20$, $SD = 0.46$; $t[38] = 16.14$, $p < .001$) and OAs ($M = 1.22$, $SD = 0.42$; $t[38] = 18.21$, $p < .001$), indicating that both groups were able to distinguish Kinematic Difference from No Kinematic Difference trials. We conducted a mixed ANOVA on d' with size of kinematic signal (large or small based on extent of implied change in velocity) as a within-participants factor, and age group as a between-participants factor (see online supplementary materials for tables of descriptive and inferential data). Unsurprisingly, there was a main effect of size of kinematic signal, confirming that participants were more sensitive to the signal when there was greater velocity change ($F[1, 76] = 274.27$, $p < .001$, $\eta_p^2 = 0.78$). Importantly, there was no significant main effect of age group, with OAs and YAs exhibiting equivalent sensitivity toward changes in velocity, $F(1, 76) = 0.03$, $p = .87$; see Figure 2B. The interaction between age group and size of kinematic signal was also not significant, $F(1, 76) = 2.39$, $p = .13$.

To assess whether the nonsignificant difference between OA and YA sensitivity toward changes in velocity reflected the absence of an effect rather than a lack of statistical power, we calculated a Bayes Factor (BF_{01}), representing the ratio of evidence for the null model over evidence for the alternative model. $BF_{01} > 3$ has been assumed to provide good evidence to support the null (Jeffreys, 1939; Lee & Wagenmakers, 2014). Conducting a Bayesian independent samples *t* test in JASP (Love et al., 2015) revealed evidence for the null hypothesis over the alternative that OAs and YAs have differential sensitivity to changes in velocity ($BF_{01} = 4.18$). Experiment 2 therefore demonstrates equivalent performance between OAs and YAs with similar stimuli and task requirements to Experiment 1, but in a task that required detection of a kinematic rather than postural cue.

Experiment 3

Based on the findings in Experiments 1 and 2, we hypothesized that OAs would exhibit impairments in detecting affective states conveyed primarily through postural information but would be relatively preserved in detecting those conveyed primarily through kinematics. In other words, they would exhibit impairments when detecting affective states conveyed through the cues that they have relative difficulty perceiving. This hypothesis was examined in Experiment 3 where we studied the ability of OAs to recognize happy, angry and sad affective states from PLDs.

Previous studies have indicated that the identification of some affective states relies more heavily on kinematic cues such as velocity and acceleration whereas others can be identified more easily from postural information. The specific pattern of these dependencies will likely differ depending upon the stimulus set—and certainly also between bodily and facial cues—but previous work in YAs has revealed much about the sources of information observers use to make affective state judgments in the present stimulus set. Edey et al. (2017) found that velocity cues were of greater importance when detecting anger (rapid, jerky movement) and sadness (slow, sluggish movement) than when detecting happiness in these stimuli, given that judgments were influenced to a greater extent by removal of the cues (see also Barliya, Omlor, Giese, Berthoz, & Flash, 2013; and note that variation in acceleration tracked the variation in velocity). Additionally, when the kinematic cues were removed from these stimuli leaving only postural cues, participants detected happiness more readily than anger or sadness (happiness relative to sadness [$t(86) = 2.8$, $p = .006$] and anger [$t(86) = 3.6$, $p = .001$]), suggesting that happiness detection in these stimuli relied more upon postural features than anger or sadness detection. We therefore predicted based on Experiments 1 and 2 that OAs would exhibit impaired detection of happiness due to deficient posture processing, and relatively intact detection of anger and sadness, due to intact kinematic processing.

Method and Participants

Two groups participated in Experiment 3, 46 YAs aged 35 or under ($M = 27.7$, $SD = 4.8$ years, 32 females) and 37 OAs aged 60 or older ($M = 71.8$, $SD = 7.2$ years, 23 females). The results of three OAs were excluded because d's could not be calculated due to 100% false alarm rates or 0% hit rates in at least one condition.[2]

We obtained WASI scores for 25 OAs and 30 YAs in Experiment 3. Raw OA scores ($M = 70.8$, $SD = 6.9$; FSIQ2 equivalent = 129.0) did not differ significantly from raw YA scores ($M = 71.1$, $SD = 6.8$, FSIQ2 equivalent = 121.5; $t[53] = 0.18$, $p = .86$).

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[2] Of those excluded, all three had 100% false alarm rates in the happy condition, and one of these also had 0% hit rates in sad and angry conditions (i.e. classified PLDs as happy at every opportunity, and never classified PLDs as sad or angry).

To ensure groups were matched for other traits that may be associated with deficits in emotion recognition, we also obtained scores on the Toronto Alexithymia Scale (TAS-20) and the Beck Depression Inventory (BDI) for 25 OAs and 18 YAs. Scores did not differ according to age group in relation to the TAS-20 (OA M = 45.20, *SD* = 8.80; YA M = 45.39, *SD* = 7.19; $t[41] = 0.08$, $p = .94$) or BDI (OA M = 7.80, *SD* = 5.09; YA M = 8.72, *SD* = 6.44; $t[41] = 0.52$, $p = .60$).

Stimuli. Affectively Neutral trials presented the same four PLDs used in Experiments 1 and 2. Affective State trials presented other stimuli from the same original set (Nackaerts et al., 2012) but where the actors conveyed happiness, sadness, or anger. The sad PLD moved with low velocity and acceleration, taking fewer steps per second than the affectively neutral walker (sad: mean velocity = 2.03 pixels/frame [*SD* = .73], mean acceleration = .73 pixels/frame^2 [*SD* = .09]; neutral: mean velocity = 3.91 pixels/frame [*SD* = 1.69], mean acceleration = 1.30 pixels/frame^2 [*SD* = .21]). In contrast, the happy (mean velocity = 5.91 pixels/frame [*SD* = 2.54]; mean acceleration = 1.99 pixels/frame^2 [*SD* = .40]) and angry walkers (mean velocity = 6.97 [*SD* = 2.87]; mean acceleration = 2.49 pixels/frame^2 [*SD* = .37]) both moved with higher velocity and acceleration, but where the difference relative to affectively neutral walkers was especially exaggerated in the angry PLD (see Supplementary Videos). Half of the videos were trimmed to equalize step cycle (two cycles) and half to equalize duration (two seconds).

This combination of two actors, two viewing angles, and equalization by duration and step cycle, generated eight Affective State videos per affective state, while there were four Affectively Neutral videos.

Procedure. The procedure matched Experiments 1 and 2, except that participants were asked to consider which affective state, if any, was conveyed in the PLD. They were told that this state could be angry, sad, happy, or none of these. After each video, participants were asked “Was the person happy?,” “Was the person sad?,” or “Was the person angry?” Giving participants a two alternative forced choice task departed from typical emotion recognition studies in the literature because we aimed to isolate sensitivity from response biases, and such a design is recommended for orthogonalization (see Yeshurun, Carrasco, & Maloney, 2008).

Trials were presented to each participant in two blocks of 84 PLD videos (16 Affective State and 12 Affectively Neutral trials per affective state) and presentation order was randomized within each block, so participants were not aware when watching a video which affective state would be probed. Like in Experiments 1 and 2 participants saw no videos containing a signal other than the target signal, for example trials in which the person was happy and they were asked whether they were angry.

Results and Discussion

One sample *t* tests confirmed that d' was significantly positive for both YAs and OAs for all three affective states tested, indicating that both groups were able to distinguish Affective State from Affectively Neutral trials (all *t*s > 2.66, all *p*s < 0.007). We carried out a mixed ANOVA on the d' data, with target affective state (happy, sad, or angry) as the within-participants factor and age group as the between-participants factor (see online supplementary materials for tables of descriptive and inferential data). Greenhouse-Geisser corrections were applied where appropriate. There was a significant main effect of affective state ($F[2,162] = 138.06$, $p < .001$, $\eta_p^2 = 0.63$), with participants across age groups being most sensitive in the sad condition and least sensitive in the happy condition. Importantly, this main effect was qualified by a significant interaction between affective state and age group ($F[2, 162] = 9.62$, $p = .001$, $\eta_p^2 = 0.11$). Follow-up tests indicated that OAs were significantly less sensitive to happiness than the YAs, $t(81) = 3.05$, $p = .003$, equally sensitive to anger, $t(81) = -1.18$, $p = .24$ and, interestingly, more sensitive to sadness, $t(81) = -2.20$, $p = .03$; see Figure 2C.

Although, at a group level, d's were significantly positive for both groups in all three conditions, the happy condition was most difficult for both groups and some participants had negative d' (in addition to the exclusions noted above, 7 YAs and 12 OAs fell into this category). Since all participants with negative d' in the happy condition had significantly positive d' in the sad and angry conditions, it is unlikely that these arose from confusion over the task instructions. However, it is possible that, while some of those with negative d' were insensitive to informative visual cues, others may have been sensitive to the cues but categorized neutral PLDs as happy and vice versa. However, even excluding all 19 participants with negative d's (all in the happy condition), there remained a significant interaction between age group and target affective state ($F[2, 124] = 4.62$, $p = .02$, $\eta_p^2 = 0.07$), and follow-up tests indicated OAs remained significantly less sensitive to happy PLDs than YAs, $t(62) = 2.31$, $p = .02$.

To summarize, OAs were impaired in detecting those affective states thought to be conveyed predominantly through the cues they were shown to be impaired in perceiving in Experiments 1 and 2 (posture; i.e., happiness) but not in detecting those conveyed primarily through the cues they were shown to process similarly to YAs (kinematics; i.e., sadness and anger).

Cross-Experiment Comparisons

By design, most of our participants completed all three experiments. This subset included 29 YAs ($M = 27.3$, $SD = 4.7$ years, 21 females) and 24 OAs ($M = 74.8$, $SD = 6.8$ years, 14 females). Among this subset, the patterns of significance (both main effects and interactions) were the same as with the full samples, and there was a task (i.e., Experiment) by age group interaction (see online supplementary materials). Additionally, data from these participants enabled us to carry out partial correlations to verify the assumptions underlying Experiment 3. These correlation analyses verified that within our dataset, happiness perception relied more heavily upon postural than kinematic cues, and anger and sadness perception more heavily upon kinematic cues. However, we note that these comparisons are relative rather than absolute given that our study was not optimally powered for detecting such correlational effects and therefore null effects should be treated with caution. The details of these analyses are provided in the online supplementary materials.

General Discussion

The present experiments tested the hypothesis that perceptual disturbances may contribute to OAs’ deficits in emotion recognition, using “point light display” body movement stimuli. The data demonstrated difficulty processing postural cues in OAs relative to YAs (Experiment 1), alongside intact processing of kinematic cues (Experiment 2). In support of our hypothesis, the OAs also exhibited difficulty recognizing only the affective state (happiness) conveyed predominantly through the cue toward which Experiment 1 had demonstrated them to be impaired in processing (posture; Experiment 3).

These findings are therefore consistent with the hypothesis that difficulties in recognizing affective states in OAs relate to reduced sensitivity to the perceptual cues signaling those states. In fact, not only were the emotion recognition deficits larger for those emotions predominantly conveyed by perceptual cues they were impaired in processing, they were absent for emotions predominantly conveyed by intact perceptual cues. This pattern may appear inconsistent with the popular hypothesis that deterioration in the "social brain"—involving the orbitofrontal cortex, cingulate cortex and amygdala—is responsible for broad deficits in emotion recognition in OAs (e.g., Ruffman et al., 2008). Given that this is the network implicated in the "accurate perception of the dispositions and intentions of other individuals" (p. 367; Brothers, 2002), it appears to follow from a strong version of the "social brain" account that problems with emotion recognition are caused directly by problems in post-perceptual mechanisms for computing internal states. Under this interpretation, this specific pattern of impairments in Experiment 3 would not have been predicted. However, given that the account is somewhat underspecified at the cognitive level, it is also possible that one could use the present findings to flesh out the account and suggest that the "social brain" deteriorates due to reduced perceptual input across age.

One could speculate that the deficit OAs show in postural processing is related to difficulties with visual configural processing. For instance, OAs exhibit smaller "global precedence" effects, such that the speed advantage typically observed in recognizing the global form of objects in comparison with local features is reduced in OAs (Insch et al., 2012; Lux et al., 2008; Oken et al., 1999; Slavin et al., 2002; see also Murray, Halberstadt, & Ruffman, 2010; Slessor, Riby, & Finnerty, 2013; Spencer et al., 2016). Postural information requires computing the relative position of effectors—in the case of Experiment 1, the position of the dot representing the wrist on one side of the body relative to those representing other body parts—and therefore deficits processing configural information would yield posture perception difficulties. Although perception of kinematic features may often require configural processing, the task presented in Experiment 2 likely did not. Specifically, participants could perform the required judgment by focusing on any single point on an arm or leg. Therefore, under this hypothesis, the present findings would indicate that deficits in perceiving posture will typically be found in OAs because the nature of this cue is typically configural, but problems in perceiving kinematics may depend upon whether the kinematic feature required configural processing (see Di Domenico, Palumbo, Mammarella, & Fairfield, 2015; Grainger, Henry, Phillips, Vanman, & Allen, 2017). Possible reasons for age-related changes in configural processing include narrowing of the attentional field based on retinal deterioration (Kosslyn, Brown, and Dror, 1999) and changes in patterns of hemispheric asymmetry (Dolcos, Rice, & Cabeza, 2002). Future research should further examine the functional and neural basis of the sensory deficit generating this pattern across postural and kinematic cues. It could also consider how far effects generalize to more naturalistic environments than those provided by sparse PLDs (although it is of note that previous studies have indicated OAs do not have difficulties in interpreting PLDs per se, including those conveying emotional information—see Ruffman et al., 2009).

Our findings highlight a methodological issue in relation to previous literature suggesting relatively emotion-general deficits in recognition from facial, vocal and bodily cues (e.g., Insch et al., 2012; Ruffman et al., 2008; Spencer et al., 2016; note that the previous literature has typically found intact recognition of disgust). This literature has not allowed for a specific assessment of sensitivity to the signal, with the majority of studies requiring participants to label the affective state presented, from multiple response options, and calculating the percentage accuracy. These procedures allow it to be inferred that individuals have difficulties in correctly labeling emotions but cannot determine whether these difficulties reflect poor signal sensitivity or response biases (see Isaacowitz et al., 2007, for a discussion of this issue). For instance, several studies have indicated intact performance for happiness recognition and, given a possible "positivity bias" in OAs (Carstensen & Mikels, 2005), it is particularly important to dissociate sensitivity from bias effects in this context. However, future work must examine whether OA deficits in sensitivity to affective states are *only* determined by impaired perception of cues toward those states, or whether there are other contributing factors.

More broadly, these findings highlight how difficulties in perceptual processing can generate problems in emotion recognition. Although the requirement for perceptual processing in emotion recognition is widely acknowledged, its specific contribution to patterns in processing is often neglected, with studies considering only broad visual acuity via self-report both in aging studies and those examining other populations. For instance, difficulties in emotion recognition in autism may not stem from lower empathy, as has classically been assumed (Baron-Cohen, 2009), but rather perceptual atypicalities (Brewer et al., 2016; see also Cracco, De Coster, Andres, & Brass, 2015; Hayes, Andrew, Elliott, Gowen, & Bennett, 2016). In line with the present findings, it has also recently been found that individuals with developmental prosopagnosia—a deficit hypothesized by some to result from atypical configural perceptual processing (Avidan, Tanzer, & Behrmann, 2011)—also have emotion recognition difficulties (Biotti & Cook, 2016).

In conclusion, the present findings suggest that difficulties in recognizing affective states from bodily cues in OAs may be related to difficulties in perceiving the perceptual cues signaling those states. These findings demonstrate more widely how it is essential to consider the contribution of perceptual processes to emotion recognition.

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