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Global form and motion processing in healthy ageing

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ABSTRACT

The ability to perceive biological motion has been shown to deteriorate with age, and it is assumed that older adults rely more on the global form than local motion information when processing point-light walkers. Further, it has been suggested that biological motion processing in ageing is related to a form-based global processing bias. Here, we investigated the relationship between older adults' preference for form information when processing point-light actions and an age-related form-based global processing bias. In a first task, we asked older (>60 years) and younger adults (19–23 years) to sequentially match three different point-light actions; normal actions that contained local motion and global form information, scrambled actions that contained primarily local motion information, and random-position actions that contained primarily global form information. Both age groups overall performed above chance in all three conditions, and were more accurate for actions that contained global form information. For random-position actions, older adults were less accurate than younger adults but there was no age-difference for normal or scrambled actions. These results indicate that both age groups rely more on global form than local motion to match point-light actions, but can use local motion on its own to match point-light actions. In a second task, we investigated form-based global processing biases using the Navon task. In general, participants were better at discriminating the local letters but faster at discriminating global letters. Correlations showed that there was no significant linear relationship between performance in the Navon task and biological motion processing, which suggests that processing biases in form- and motion-based tasks are unrelated.

1. Introduction

Biological motion can be defined as any movement pattern, produced by the body of a human or animal, and is an important visual cue that helps us to perceive the facial and body movements of others so that we can understand and predict their behaviour (e.g., Blake & Shiffrar, 2007). Successful decoding of biological motion information provides us with information about movement direction and intention but also about mental states, personality traits, and emotions (Bonda, Petrides, Ostry, & Evans, 1996; Dittrich, Troscianko, Lea, & Morgan, 1996; Heberlein & Saxe, 2005; Insch, Bull, Phillips, Allen, & Slessor, 2012). The ability to perceive biological motion is commonly tested using point-light animations, which were first introduced by Johansson (1973). Point-light animations consist of dots or light points that mimic or represent the joint movements of a moving person. By integrating the motion of those dots, it is possible to recognise a human figure. The perception of biological motion is very robust and from point-light animations it is possible to extract information about gender (Kozlowski & Cutting, 1977; Pollick, Kay, Heim, & Stringer, 2005), identity (Kozlowski & Cutting, 1977; Loula, Prasad, Harber, & Shiffrar, 2005; Troje, Westhoff, & Lavrov, 2005), or emotions (Dittrich et al., 1996; Roether, Omlor, & Giese, 2008; Spencer, Sekuler, Bennett, Giese, & Pilz, 2016), and to identify a wide range of different actions (Fig. 1; Vanrie & Verfaillie, 2004).

Interestingly, recent studies have shown that biological motion perception changes with age (Norman, Clayton, Shular, & Thompson, 2004; Billino, Bremmer, & Gegenfurtner, 2008; Pilz, Bennett, & Sekuler, 2010; Insch et al., 2012; Legault, Troje & Faubert, 2012). It has been found that older adults have difficulties detecting point-light walkers in noise (Billino et al., 2008; Pilz et al., 2010), need more time to process biological motion than younger adults (Norman et al., 2004; Pilz et al., 2010) and have difficulties discriminating walkers from short distances (Legault et al., 2012). In a recent study, Pilz et al. (2010) suggested that older and younger adults use different kinds of information present in point-light animations. Point-light animations contain local motion information, the local motion trajectories of the single dots, and global form information, which is revealed when integrating the single dots into a global percept at each point in time. The global motion of the animated figure can be derived from the integration of the local motion trajectories of the single dots or by integrating the global form information over time (e.g., Giese and Poggio, 2003).

Pilz et al. (2010) investigated the contribution of form and motion information to age-related changes in biological motion processing by presenting three different kinds of upright and inverted point-light

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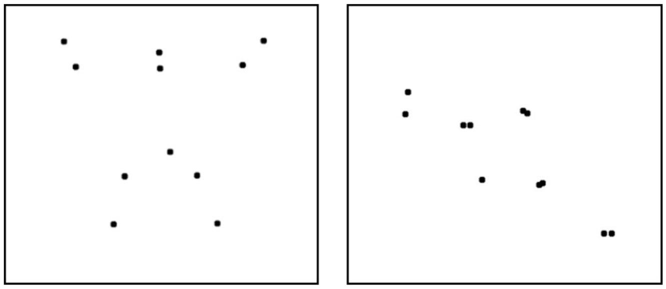

Fig. 1. Still frames of jumping (left) and driving (right) point-light actions (Vanrie & Verfaillie, 2004).

walkers: normal walkers that contained local motion, and global form information, random-position walkers that contained primarily global form information (adapted from Beintema & Lappe, 2002), and scrambled walkers that contained preserved local motion information, but disrupted global information (e.g. Bertenthal & Pinto, 1994; Thornton, Pinto, & Shiffrar, 1998; Troje & Westhoff, 2006). Participants had to discriminate the walking direction of the stimuli. Pilz et al. (2010) found that at longer stimulus durations older adults were as good as younger adults at discriminating the walking direction for upright normal and random-position walkers. Interestingly, older adults had difficulties discriminating the walking direction for inverted normal walkers, but at longer stimulus durations performed as well as younger adults for inverted random-position walkers. These results indicate that older adults are better at discriminating the motion direction for less familiar stimuli when local motion information is absent. Pilz et al. (2010) therefore suggested that older adults have difficulties integrating global form and local motion information as efficiently as younger adults. More recently, Insch et al. (2012) investigated the relationship between global form and biological motion processing by relating performance on a point-light action discrimination task with performance in a Navon type task (Navon, 1977). The Navon task is often used to investigate a visual preference for processing the global information contained within a stimulus, otherwise known as global precedence. Global precedence occurs when the global and local levels of a stimulus are incongruent, and the global stimulus interferes with processing the local stimulus to a greater degree, than the local stimulus interferes with processing the global stimulus (e.g. Insch et al., 2012; Navon, 1977).

The original Navon task requires the identification of letters. Navon letters consist of many small letters (local stimuli) that are arranged to form a larger letter (global stimulus; Fig. 2). The global and local letters can be the same (consistent) or different (inconsistent). Participants are required to identify either the global or local letters. By relating performance in the Navon task and point-light action discrimination, Insch et al. (2012) found that, across all ages, the ability to decode emotions and actions from point-light displays was positively related to a global-processing bias, i.e., a preference for processing the global letters. More interestingly however, older adults exhibited a local processing bias in the Navon task, i.e., a preference for processing the local letters, which is in accordance with previous studies (Lux, Marshall, Thimm, & Fink, 2008; Oken, Kishiyama, Kaye, & Jones, 1999; Slavin, Mattingley, Bradshaw, & Storey, 2002; Staudinger, Fink, Mackay, & Lux, 2011). Overall, older adults performed worse on the biological motion task than younger adults. However, as shown by mediation analyses, age-differences in global to local processing did not entirely account for age-related changes in biological motion discrimination.

An age-related local processing bias as found by Insch et al. (2012) seems to be in contrast to the global form advantage for biological motion stimuli that was found by Pilz et al. (2010). Therefore, to assess the exact relationship between the age-related form-based local processing bias (Insch et al., 2012) and a potential form-based global processing advantage for point-light walkers in ageing (Pilz et al., 2010), this study combined the recent findings and stimuli by Insch et al. (2012)

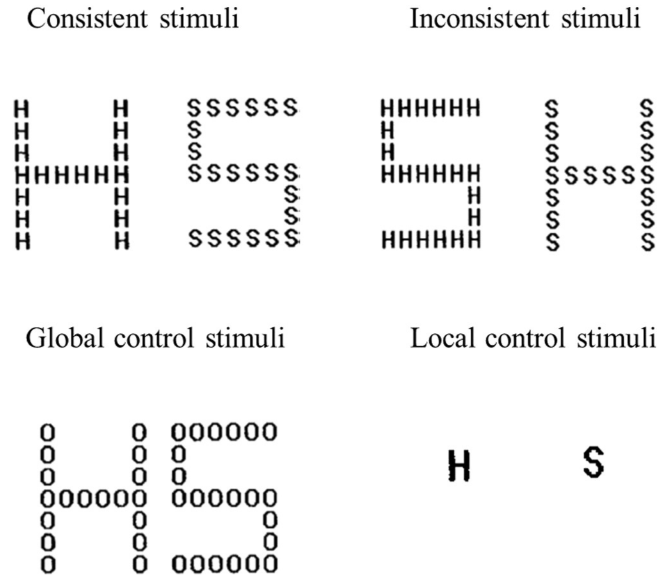

Fig. 2. Examples of Navon stimuli as adapted from Roux and Ceccaldi (2001) for stimuli for which the local letters are the same as the global letter (consistent, upper left), the local letters are different from the global letter (inconsistent, upper right), and control stimuli for which the local information is irrelevant to the task (control, lower left) or the global information is absent (control, lower right).

and those of Pilz et al. (2010). Rather than using a single computer-generated so called Cutting point-light walker as was used in Pilz et al. (2010), this study used complex motion captured actions (Vanrie & Verfaillie, 2004). It has been suggested that motion-captured walkers provide stronger local motion signals than Cutting walkers (Saunders, Suchan, & Troje, 2009), allowing us to better differentiate between the contributions of local motion and global form information for point-light walker processing. To assess the importance of form and motion information in biological motion perception, a matching task was employed, in which the first stimulus contained either local motion information, global form information, or both, and the second stimulus always contained local motion and global form information. Participants simply had to indicate whether the first and second stimulus showed the same action or not. Using this task, we were able to assess which kind of information older and younger adults preferentially utilise for biological motion processing. Based on the findings from Pilz et al. (2010), we anticipated that older adults would be worse at matching scrambled actions that primarily contain local motion compared to random-position actions that primarily contain global form information. In addition, we used the Navon task to investigate perceptual processing styles for both age groups. We expected that, similar to previous studies, both age groups would be faster at responding to the global than the local Navon letters, therefore exhibiting global precedence. In addition, we wanted to assess how the increased accuracy for local compared to global letters in older adults found by Insch et al. (2012) relates to the form-based processing advantage suggested by Pilz et al. (2010). We therefore correlated performance in the biological motion task with performance in the Navon task to investigate whether age-related differences in perceptual processing styles in the form-based Navon task accounted for the advantage of form over local motion information in biological motion processing.

2. Methods

2.1. Participants

18 younger participants ($M = 19.9$ years; SD = 1.2; Range = 19–23; 3 males) and 20 older participants ($M = 65.4$ years; SD = 3.9; Range = 61–78; 4 males) took part in the experiment. 1 younger and 5 older