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JOINT ATTENTION IS SLOWED IN OLDER ADULTS

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Background/Study Context: *The automatic propensity to orient to the location where other people are looking is the main way of establishing joint attention with others. Whereas joint attention has been mostly investigated with young adults, the present study examines age-related differences in the magnitude and time course of joint attention.*

Methods: *Forty-three community-dwelling seniors and 43 younger adults performed a visuospatial task. The procedures closely follow those of gaze-cueing tasks commonly used to investigate joint attention.*

Results: *The findings revealed that a gaze-cueing effect occurs for* both *younger and older adults, with an equivalent average magnitude but with different time courses. The effect peaks later in older adults.*

Conclusion: *Age-related differences in joint attention could be linked to a more general cognitive slowing rather than to poorer basic social skills. The present study adds to the growing interest in gerontological research regarding social attention.*

The use of another person's eye gaze as a cue to shift attention is a fundamental skill in social interactions (for a review, see Frischen, Bayliss, & Tipper, 2007). The other person's gaze triggers reflexive, automatic attention shifts in the corresponding direction in the observer. When attention is directed toward a particular location, the visual processing of targets in that location is facilitated, resulting in faster reaction times (RTs) to detect or discriminate targets at that location than in locations that are not gaze-cued (the *gaze congruity effect* or *gaze-cueing effect*, e.g., Bayliss, di Pellegrino, & Tipper, 2005; Driver et al., 1999; Friesen & Kingstone, 1998). This automatic propensity to orient to the same location where other people are looking is the main way of establishing joint attention with others (Emery, 2000; Moore & Dunham, 1995). Joint attention is fundamental to human learning, as well as to the development of social competence throughout the life span. It has been widely studied in infants for decades (e.g., Farroni, Massaccesi, Pividori, & Johnson, 2004;

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Scaife & Bruner, 1975), as it is key to the development of social cognition in early life (see Striano & Reid, 2008, for a review). In contrast, little research has been conducted with older adults. In keeping with previous findings of age-related impairments in more complex aspects of social perception (e.g., theory of mind and emotion perception; Slessor, Phillips, & Bull, 2007; Sullivan & Ruffman, 2004) or interpersonal behavior (Henry, von Hippel, & Baynes, 2009; von Hippel & Dunlop, 2005), age-related declines in the ability to establish joint attention have been found: Older adults showed a significant gaze-cueing effect, as their RT was facilitated when the target appeared in the gazed-at location, but the effect was significantly smaller than for younger adults (Slessor, Laird, Phillips, Bull, & Philippou, 2010; Slessor, Phillips, & Bull, 2008). Recent findings from Slessor et al., 2016 even show that older adults do not use eye-gaze cues to engage in joint attention, highlighting social difficulties for decoding critical information from the eye region.

The time course of the gaze-cueing effect is a key feature for a better understanding of the joint attention process. Time course is commonly used in visuospatial cueing tasks to provide a unique window into the mechanisms that facilitate or inhibit the covert orienting of attention to the locations of cued targets (Posner & Cohen, 1984; Wilson & Pratt, 2007). It is examined by manipulating the delay period between the onset of the cue and the onset of the target (i.e., cue-target onset asynchrony, or CTOA). The time course of joint attention is well known for young people. Previous investigations have consistently demonstrated that the gaze-cueing effect emerges quickly (i.e., at short CTOAs of 105 to 300 ms) and that this facilitation effect exhibits a relatively short time course, disappearing by a 1005-ms CTOA (see Frischen et al., 2007, for review). Early research found age-related differences in the time course in several attention tasks, including visual cueing tasks (e.g., Castel, Chasteen, Scialfa, & Pratt, 2003; Madden, Connelly, & Pierce, 1994). No study has, however, examined the time course of joint attention in older people. The present study asks then to what extent the time course of joint attention is affected by aging. Because older adults may be slower to engage spatially based attention (e.g., Castel et al., 2003), it is hypothesized that joint attention takes longer to build up in older adults, in comparison with young people.

METHODS

Participants

Two groups of participants were recruited: 43 community-dwelling seniors (20 women, 23 men; mean age: 69.16 years, $SD = 3.12$), and 43 younger adults (22 women, 21 men; mean age: 24.05 years, $SD = 1.91$). All gave their informed consent, and they were not compensated for their participation. All of the participants were free from past or present neuropsychological disorders, reported corrected-to-normal vision, and were naïve with regard to the purpose of the experiment. All older adults achieved a score greater than 27 ($M = 28.67$, $SD = 0.97$) in the Mini-Mental State Exam (Folstein, Robins, & Helzer, 1983), which is the recommended cutoff point for normal cognitive functioning (Folstein et al., 1983).

Apparatus and Procedure

The experiment took place in a dimly illuminated, sound-attenuated room. Participants sat approximately 60 cm from the 43-cm (17-in.) computer monitor on which experimental

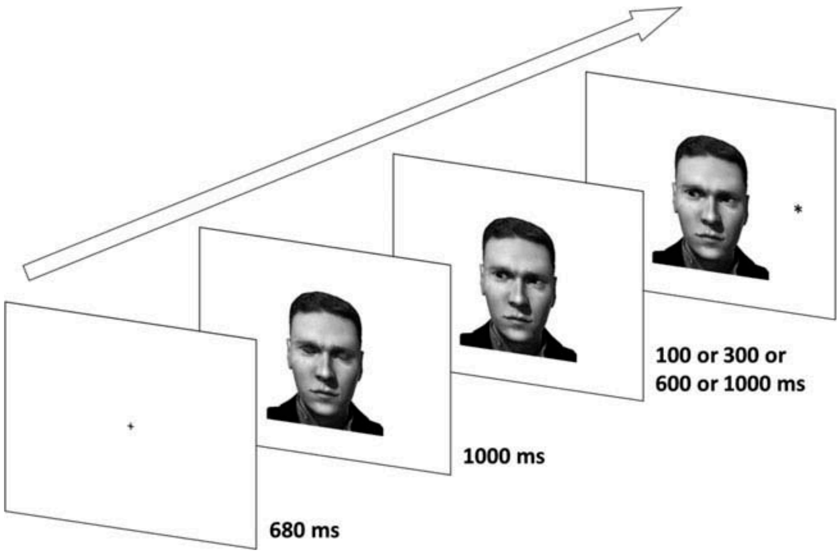

Figure 1. Illustration of stimulus sequence for gaze-cueing task. In the trial illustrated, the target (the asterisk) appears on the incongruent side.

stimuli were presented. Stimuli consisted of two realistic synthetic full-face portraits (a young male face and a young female face), each with two eye-gaze directions (left or right). The degree of gaze aversion was 0.45° from direct forward. The image of each full-face portraits measured 16 cm wide and 20 cm high (with the eye region subtending 2 cm wide and 1 cm high). Each trial began with a fixation cross presented in the center of the screen. After 680 ms, the fixation cross disappeared, and a face with eyes closed appeared in the center of the screen. After 1000 ms, the eyes of the face opened with the gaze averted to either the left or the right. Following this, a target (an asterisk approximately 1 cm^2) appeared to either the left or the right of the face image after a variable CTOA (100, 300, 600, or 1000 ms). Participants were instructed to respond as quickly and as accurately as possible to the presentation of the target by making a keypress response with the left hand (S), when the target appeared on the left, and the right hand (L) when the target appeared on the right. The face cue and target remained on the screen until a response was made. Figure 1 illustrates the sequence of events on a trial.

The experiment took place in two separate blocks, one with the male face and one with the female face, in a random order across participants. In each of these two blocks, the participant first performed 16 familiarization trials that were not analyzed, followed by three test blocks consisting of 32 trials each, for a total of 192 trials overall. In half of these trials, gaze direction was congruent with the subsequent position of the target. In the remaining trials, gaze direction of the face was incongruent with the subsequent target location. Gaze-cue direction (left or right) and target position (left or right) occurred equally often and were presented in a pseudorandom order. The four CTOAs occurred equally often. There were 24 total trials for each combination of congruent/incongruent and CTOA. Participants were informed that the direction in which the eyes looked was not predictive of the location of the target or of when it would appear.

RESULTS

Errors (0.63%) and responses slower than 2500 ms, faster than 200 ms, or 2 standard deviations above or below the participant's individual mean in each condition (4.92%) were removed from reaction time (RT) analysis. To test for age-related differences in RT on the gaze-cueing task, a mixed model 2 × 2 × 4 analysis of variance (ANOVA) was conducted with age of participants (younger vs. older) as a between-subjects factor and cue congruity (congruent and incongruent) and CTOA (100, 300, 600, and 1000 ms) as within-subjects factors. This analysis revealed a significant main effect of cue-target congruity, $F(1, 84) = 57.83$, $p < .01$, $\eta^2_p = .41$, with faster responses to congruent ($M = 415.46$ ms, $SD = 92.63$ ms) than to incongruent ($M = 426.01$ ms, $SD = 92.98$ ms) trials. The main effect of CTOA also reached significance, $F(3, 252) = 86.25$, $p < .01$, $\eta^2_p = .51$, with RT decreasing at longer CTOA, as did the effect of age of participants, $F(1, 84) = 193.27$, $p < .01$, $\eta^2_p = .70$, with older adults ($M = 495.41$ ms, $SD = 62.09$ ms) responding more slowly overall than younger adults ($M = 346.06$ ms, $SD = 47.35$ ms).

The cue congruity by CTOA interaction also reached significance, $F(3, 252) = 4.19$, $p < .01$, $\eta^2_p = .05$, with the beneficial effect of gaze cueing changing over time.

Of interest, the cue congruity by age of participant interaction was not significant, $F(1, 84) = 0.19$, $p = .66$, indicating that the mean magnitude of the gaze-cueing effect did not differ in the two age groups. The cue congruity by CTOA by age of participant three-way interaction was, however, significant, $F(3, 252) = 5.78$, $p < .01$, $\eta^2_p = .06$, meaning that the influence of the CTOA on the magnitude of gaze-cueing effect depended on the age group.

To explore the three-way interaction, we calculated congruity, or gaze-cueing effect, scores for each person in each CTOA condition, $RT_{INCONGRUENT} - RT_{CONGRUENT}$. The interaction is shown in Figure 2. There was a significant effect of CTOA for younger adults, $F(3, 126) = 5.78$, $p < .001$; follow-up tests using the Bonferroni procedure showed that the gaze-cue effect peaked at 300 ms, with means for 100 and 300 ms significantly greater than that for 1000 ms. There was also a significant effect of CTOA for older adults, $F(3, 126) = 4.70$, $p < .01$; follow-up tests showed the gaze-cue effect peaked at 600 ms, with the mean for 600 ms significantly greater than that for 100 ms. The gaze-cueing effect

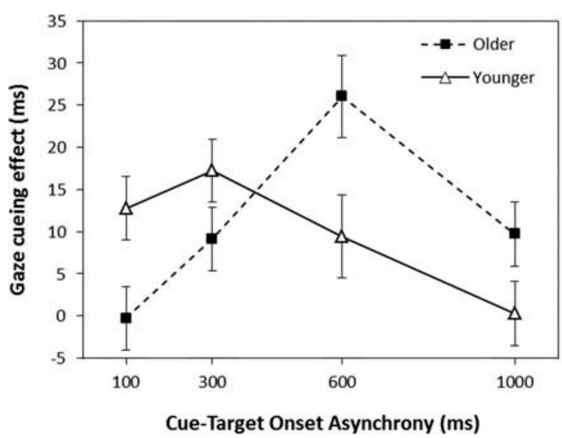

Figure 2. Gaze-cueing effect ($RT_{INCONGRUENT} - RT_{CONGRUENT}$) as a function of age group and cue-target onset asynchrony.

at the peak was larger for older adults ($M = 26.02$ ms, $SD = 40.47$ ms) than for younger adults ($M = 17.24$ ms, $SD = 18.51$ ms), but the difference was not significant, $t(84) = 1.29$, $p = .20$.

An alternative approach to decomposing the three-way interaction is to compare the gaze-cueing effects for younger and older adults at each CTOA. *t* tests with the use of Holm-Bonferroni corrections to counteract the problem of multiple comparisons revealed no significant difference between younger and older adults.

DISCUSSION

There is increasing evidence that basic orienting of attention is influenced by individual differences, such as gender, autistic tendencies (e.g., Bayliss et al., 2005), anxiety (e.g., Mathews, Fox, Yiend, & Calder, 2003), or age (e.g., Slessor et al., 2008, 2010). The present study was specifically designed to gain a more comprehensive understanding of age-related impairments in joint attention by studying the magnitude and time course of gaze following for older adults, in comparison with younger people. Overall, our findings revealed that the gaze-cueing effect occurs for *both* younger and older adults, with an equivalent peak magnitude, but with a different time course of joint attention.

Consistent with previous findings (e.g., Bayliss et al., 2005; Driver et al., 1999; Friesen & Kingstone, 1998), the present experiment confirms that gaze cues are robust cues to attention, even when the other person's gaze direction was not predictive of the location of the target or when it would appear. As such, gaze cueing can be regarded as reflexive in the sense that it cannot be suppressed. Furthermore, although older participants responded more slowly overall in the experimental task, our results did not show an overall advantage for young, in comparison with older adults, in the magnitude of cueing effects. This result goes beyond of those of Slessor and colleagues (2008, 2010) who found that older adults' RT was facilitated when the target appeared in the gazed-at location, but to a significantly lesser extent than for younger adults. In their studies, Slessor and colleagues used only CTOAs from 220 to 500 ms. These choices of CTOAs may have been responsible for the apparently greater gaze-cue effect in the younger adults. Our results indeed showed that the peak cueing effect occurred at 300-ms CTOA for younger people, consistent with previous studies (see Frischen et al., 2007, for a review), but the effect takes longer to build up for older adults, not peaking until around 600-ms CTOA. Finally by 1000-ms CTOA, gaze-cue effects have mostly dissipated in both groups.

In the light of these findings, we propose that performance in joint attention could have two separate components: (a) the ability to follow other's gaze, reflected by the magnitude of the peak cueing effect; and (b) the time required to process other's gaze cue, reflected by the cueing effect peaks. Impairments in either or both of these two components could be considered as a decline in joint attention. Accordingly, the present study moderates the prior conclusions that older adults were poorer in the basic perceptual social skills, a conclusion based only on their lower peak cueing effect (Slessor et al., 2008, 2010). Here, the magnitude of the peak as well as the overall gaze-cueing effect was the same. Nevertheless, there were differences in the time course. This suggests that age-related impairments in joint attention could be due to a general reduction with increased age in the speed with which many cognitive operations can be executed (Verhaeghen, 2013). With the use of gaze cues slowed but still present, eye-gaze processing in older adults differs from that in clinical populations (e.g., autism; see Dawson, Webb, Carver, Panagiotides, & McPartland, 2004), which present large deficits in both the ability to detect eye-gaze direction and to use gaze cues to orient attention to objects of interest in the environment. Nevertheless, slowed gaze following could still have important implications for older adults' social functioning, delaying the detection and the processing of socially relevant information from the environment. For example, paying careful attention to the direction of gaze of another person could inform an observer about what this person is interested in, initiating or facilitating the social interaction. Delay in joint attention could then hinder the identification of such relevant social cues and disrupt the interpersonal relationship.

These contributions notwithstanding, and although the present study reflects the growing interest in gerontological research regarding social attention, we cannot conclude whether or not the mechanisms underlying the cueing effect observed in younger adults are the same as those underlying the cueing effect in older adults. To the best of our knowledge, only one study has examined how aging could influence the perception and processing of other's gaze. Older adults have been found to decline in the ability to detect subtle differences in eye-gaze direction (Slessor et al., 2008), which might delay their gaze-cueing effect in comparison with young adults. Whereas the present study brings conclusions about the "when," clarifying "how" gaze following differs for the older could be the topic of further investigations.

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