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Modulation of distraction in ageing

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A cueing paradigm was employed to examine modulation of distraction due to a visual singleton. Subjects were required to make a saccade to a shape-singleton target. A predictive location cue indicated the hemifield where a target would appear. Older adults made more anticipatory saccades than younger adults, and were less accurate for making an eye movement in the vicinity of a target. However, younger and older adults likewise benefited from the cue; distraction was reduced when the distractor singleton appeared in an uncued hemisphere. The ability to compensate for problems with distraction in older and younger adults through use of the precue suggests that attention to a general region of space, rather than a specific location, may be enough to modulate distraction.

Ageing has been associated with deficits in inhibitory processing that cause people to become distracted by elements that are unrelated to the current task or goal (Hasher & Zacks, 1988). Measures of eye movement behaviour have been used to investigate age-related increases in distraction. One such task that measures distraction and inhibitory processing is the antisaccade task. During the antisaccade task, a target is flashed to one side of a central fixation. When the target disappears, instead of looking at the location of the target, as would be the pre-potent response, the viewer is instructed to make an anti-saccade – initiate a saccade of equal amplitude (i.e. to the same location) in the *opposite* direction of where the cue was presented. If the viewer fails to inhibit responding to the cue, an eye movement towards the cue, a prosaccade, will be generated before the anti-saccade (Roberts, Hager, & Heron, 1994). This task requires the ability to inhibit the reflexive response of initiating a saccade towards a target and is tied to frontal lobe function; older adults and patients with frontal lobe damage make more errors than young adults (Olincy, Ross, Young, & Freedman, 1997). The effects of ageing on saccade latency in the antisaccade task is less clear, with some studies reporting age-related increases in saccade latency (Nieuwenhuis, Ridderinkhof, de Jong, Kok, & van der Molen, 2000; Olincy, *et al.*, 1997; Munoz, Broughton, Goldring, & Armstrong, 1998) and others reporting saccadic latencies similar to that of younger

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adults (Butler, Zacks, & Henderson, 1999). Whether effects of ageing are seen on measures of saccadic accuracy or latency in the antisaccade task may be related to the amount of task demands that are placed on the subject; that is, if cognitive load is relatively low, age-related differences in accuracy or latency may not be observed, but if working memory demands are taxed, such as in a dual-task situation (e.g. make a pro/antisaccade and identify the target at that location; Butler *et al.*, 1999), then age-related changes in performance may be observed (Eenshuistra, Ridderinkhof, & van der Molen; 2004; Cassavaugh, Kramer, & Peterson, 2004).

Oculomotor capture is another paradigm that has also recently been used to measure age-related increases in distraction (Colcombe *et al.*, 2003; Kramer, Hahn, Irwin, & Theeuwes, 1999). In this paradigm, subjects are required to make a saccade to a colour singleton target presented in an array and identify the letter located inside it. On half of the trials, a sudden onset occurred. If the abrupt onset is distracting, eye movements should be made to the onset, rather than to the target. Both younger and older subjects were distracted by the abrupt onset, making saccades to the distractor before correcting and making a saccade to the target (Kramer *et al.*, 1999). In an initial study (Kramer *et al.*, 1999), older and younger adults performed similarly; however, in a follow-up study, older adults made more misdirected saccades than younger adults when the onset was particularly salient (Kramer, Hahn, Irwin, & Theeuwes, 2000), suggesting that age-related differences in oculomotor capture may depend on the salience of stimuli, and/or the subjects' awareness of the distractors. Alternatively, age-related differences in the oculomotor capture task may be observed depending on whether subjects are explicitly instructed to refrain from making an eye movement to the distractor, thereby establishing a goal representation of inhibitory control that may decay faster in older than in younger adults (Colcombe *et al.*, 2003).

Work using oculomotor capture suggests that it is a powerful paradigm with which to investigate distraction and the integrity of inhibitory processing in young and older adults. Moreover, this work suggests that there is parallel programming of two saccades; a goal-directed saccade to the target singleton and a reflexive saccade to the distractor. That is, the latencies of saccades that went directly to a target were longer in the presence of a distractor than when a distractor was not present (Godijn & Theeuwes, 2002a, 2002b; Irwin, Colcombe, Kramer, & Hahn, 2000). This could occur if multiple eye movements were programmed in parallel, one to the target and one to the distractor. Even though the resulting activation is higher for the target-directed saccade, thereby causing a saccade to be directed to the target, the saccade is initiated with a higher latency due to the lateral inhibition from the saccade programme to the distractor (Godijn & Theeuwes, 2002b).

Further work has demonstrated that the use of a precue can reduce, or even eliminate, the amount of capture that occurs by distractors (non-targets). In Theeuwes, Kramer, Hahn, and Irwin *et al.* (1998), a precue was provided prior to the onset of the display that informed viewers where the target would appear. The logic here was that if subjects were provided with enough time to programme their goal-directed eye movement via the precue, the distraction from the abrupt onset would be minimal and subjects would make fewer reflexive saccades towards the distractor. Indeed, subjects appeared to use the precue to advance attention to the target location prior to the onset of the cue and were thus minimally distracted by the abrupt onset. Age-related interference effects are observed in visual search conditions in which the target can occupy varied and random locations, but these age-related distractor interference effects are reduced in non-search conditions when the target occupies a fixed location or when the subjects are cued to the location where a target will appear (Madden, 1983; Wright & Elias, 1979; Plude & Hoyer, 1986).

While it is clear from these various studies that highly specific information about the relevant target location can override the capture of distractors, it is not clear whether cueing to a general region within a display, in which there are multiple locations in which the target could appear, would also have a similar effect on the modulation of distraction. In the previous work, it appears that modulation of distraction occurs via an early programming of a goal-directed saccade. However, if distraction can be modulated by cueing a general region of space with multiple locations in which the target would appear, this would suggest that either the cueing of attention to a spatial location may be enough to modulate distraction or that multiple goal-oriented saccades are programmed in parallel, in advance of saccades that are programmed towards the onset of distractors.

The current work examines whether distraction as evidenced by oculomotor capture can be modulated in the same manner for younger and older adults when a general precue is given. Subjects performed a visual search task in which the display contains two singletons: a shape singleton and a colour singleton. Subjects were required to make an eye movement to the shape singleton (e.g. a green 'X' among green 'O's) while inhibiting responses to a colour singleton (e.g. a red 'O' amongst green 'O's and a single green 'X'). Previous work has shown that colour is a more salient feature than shape and thus here we expected subjects to be distracted by the colour singleton (Pomplun, Reingold, & Shen, 2001; Shen, Reingold, & Pomplun, 2000; Williams & Reingold, 2001). The two different shapes alternated as singletons across trials, as it has been shown that when stimuli have consistent target/distractor roles, capture by distractors is reduced (Theeuwes, De Vries, & Godijn, 2003; Wu & Remington, 2003).

To create a condition in which distraction could be modulated, subjects were presented with a central cue that perfectly predicted the hemifield in which the target will appear. The distractor, when present, could be located within the same or different hemifield as the target. Similar to Theeuwes *et al.* (1998), subjects would then be able to direct their attention, and plan their goal-directed eye movements, in advance of the presentation of the target and distractors. However, in the work to be presented here, the precue did not predict the exact location of the target, but only the hemifield in which the target would appear. This is in contrast to previous studies (e.g. Theeuwes *et al.*, 1998) in which the precue was directed to the very location of the target. Therefore, in the current work, we examine whether inhibitory problems in older adults may be modulated with a general precue that directs attention to one hemifield.

In keeping with previous work (e.g. Kramer *et al.*, 1999, 2000), increased saccadic latency (time to move the eyes) or increased saccade error (distance from the target) for conditions when the distractor is present compared with when the distractor is not present will be considered as evidence for increased distraction. Likewise, increases on either saccade error or latency for the same hemifield condition compared with the different hemifield condition will be taken as evidence that the predictive cue, which directs attention towards possible target locations, can modulate distraction. Moreover, increases on saccadic latency and saccadic error for older compared with younger adults will be taken as evidence for age-related increases in distractibility. The extent to which age interacts with distractor conditions will provide evidence for whether the precue can modulate distraction similarly in younger and older adults.

Methods

Participants

Participants in the experiment were 12 younger college-aged subjects (mean age: 21.75; range 19–25 years) and 12 older adults (mean age 70.42; range 60–79 years) from the University of Toronto and surrounding community, who took part in exchange for monetary compensation. All subjects had normal or corrected-to-normal vision. Younger and older adults did not differ on years of education, 15.17 years versus 13 years, respectively; $F(1, 22) = 2.39$, $p > .1$, or on scores for the Extended Range Vocabulary Test (ERVT, 1976); 25.33 versus 19.58, respectively, $F(1, 22) = 2.51$, $p > .1$.

Stimuli and design

The stimuli consisted of an array of 16 items arranged on an imaginary circle with a radius of 7.6° of visual angle. The target was always a shape singleton; an 'X' among 'O's or an 'O' among 'X's. The distractor was always a colour singleton; a red or green 'O' or 'X' among green or red 'O's and 'X's, respectively (see Fig. 1). The shape target and colour singleton distractor could appear at 1:30, 4:30, 7:30 or 10:30 o'clock positions. For one third of the trials, the colour singleton distractor was presented in the same hemifield as the saccade target (same hemifield). For another third of the trials, the colour singleton was presented in the opposite hemifield from the target (different hemifield); in the remaining third of the trials, the colour singleton did not appear (no singleton). The no-singleton condition, while not containing a distractor, did contain the precue like the other conditions. This condition served as a baseline to determine how attention can be modulated with a precue when a distractor is/is not present. The distractor, if present, was always presented 90° from the saccade target; thus keeping the physical distance between the saccade target and the colour singleton constant across the same- and different-hemifield conditions.

Procedure

Prior to the experiment, subjects completed an information sheet regarding age and education and the ERVT (1976). Subjects were presented with one block of 48 practice

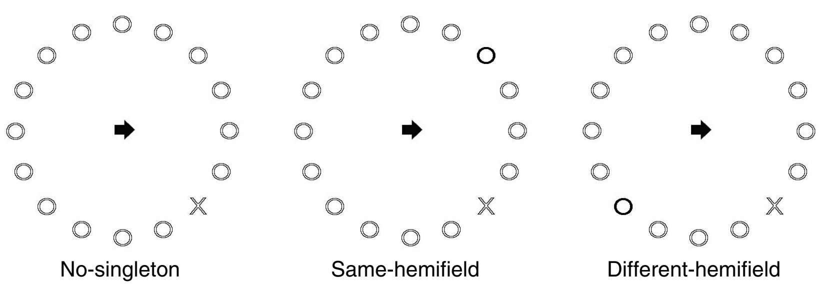

Figure 1. Example displays for the no-singleton (left), same-hemifield (centre) and different-hemifield (right) conditions. Red items shown in black; green items shown in white. Subjects must make a saccade towards the shape singleton (e.g. green 'X') in all conditions, while ignoring the colour singleton distractor (e.g. red 'O') for the latter two conditions. The identities of the shape target and colour distractor singletons were varied randomly across trials. The onset of the central arrow prior to display onset serves to cue attention to a particular hemifield and is perfectly predictive of the hemifield in which the shape target would appear.

trials followed by eight blocks of 48 trials each. Subjects were not provided with feedback during the experiment. Stimuli were displayed on a 19-inch Samsung SyncMaster 955DF monitor from a distance of 70 cm. Eye movements were collected using an SR Research Ltd. EyeLink system. The temporal resolution of the system was 4 ms. A 9-point calibration was performed at the start of the experiment followed by a 9-point calibration accuracy test. Calibration was repeated if the error at any point was more than 1°, or if the average error for all points was greater than 0.5°.

For each trial, a central fixation was presented for 300 ms, followed by a central hemifield cue (left versus right for half of the subjects; up versus down for the other half of the subjects). The cue, an arrow, remained on the screen for 400 ms. The cue was 100% predictive of saccade target hemifield location, but the cue never pointed directly at the exact target location. Subjects were told that the cue would point to the appropriate hemifield where the target would appear, and that the cue was always correct. The target could occupy any position other than those on the principal axes. The target display was shown 300–600 ms following the offset of the cue. Subjects were asked to make a saccade to the shape-singleton target as quickly and as accurately as possible, while ignoring the colour singleton. The colours of the target/distractors varied randomly across trials. The trial was terminated by a button response by the subjects when they felt they were fixating the target. Informed consent was obtained prior to testing, and written debriefing as to the nature of the experiment was provided upon completion.

Results

Reported analyses are based on the initial saccade initiated by the viewer. Since viewers were asked to terminate the trial with a button press when they were certain they were fixating the target, a corrective saccade is warranted when the initial saccade lands elsewhere other than the target location. To ensure that subjects were complying with instructions, the data were analysed with regards to the proportion of all error trials (the initial saccade did not land within 2° of the target) in which a corrective saccade was made. General task compliance from both groups of subject was very good such that the target was fixated in 99% of trials when the subjects pressed the button to end the trial.[1]

Those trials with an anticipatory saccade (i.e. failing to maintain fixation in the centre of the screen when the target display was presented) or with the first saccade initiated less than 90 ms after the target display were removed from the analysis. Older adults made more anticipatory saccades than younger subjects; 31.5% versus 7.9%; $F(1, 22) = 4.71, p < .001$.

There was no significant effect of cue direction (up/down, left/right) on saccadic latency for the younger or older subject groups when the groups were analysed separately, $Fs(1, 10) < 1$; ps $> .5$. Likewise, there was no interaction between cue direction and condition (no singleton, same hemifield, different hemifield) for either subject group analysed separately, $Fs(2, 20) < 1$; ps $> .45$, or when the subject groups

[1] *There was a small but significant effect of display condition (no distractor, same hemifield, different hemifield) on the proportion of error trials in which a corrective saccade was made, $F(2, 44) = 3.67$; $p < .05$; subjects made corrective saccades on a greater proportion of no distractor trials (99.43%) compared with the same hemifield trials, 98.50%; $t(24) = 2.86$; $p < .01$. However, there was no significant difference between the subject groups, $F(1, 22) = 2.30$; $p > .1$; and display condition did not interact with the subject group on the proportion of error trials in which a corrective saccade was made, $F(2, 44) < 1$; $p > .8$.*

were combined, $F(2, 44) < 1, p > .85$. Thus, the data for cue direction were combined in the results reported below.

Saccadic latency

As outlined by Kramer *et al.* (1999), distraction can be measured by the time with which it takes to move the eyes to fixate on the target. Evidence for age-related increases in distractibility should be manifested as increased saccadic latency compared with younger adults, particular for the conditions when a singleton is present. There was no main effect of subject group on saccadic latency, regardless of whether the initial saccade landed on the target or the distractor, $F(1, 22) < 1$; $p > .5$. Saccadic latency was shorter when the initial saccade landed on the target compared with a distractor (main effect of saccade target, $F(1, 22) = 15.28$; $p = .0001$, and this effect did not interact with subject group, $F(1, 22) = 1.5$; $p > .2$. Considering only those trials in which the initial saccade landed on the target, there were still no differences observed between the two subject groups on saccadic latencies, $F(1, 22) < 1, p > .65$.

In all conditions, attention is cued to one half of the display, but only the same/different hemifield conditions contain distractors. If subjects are distracted by the colour singleton, it should take longer for saccades to reach the target when a distractor is present compared with the no-singleton condition, given that cueing of attention is held constant across the conditions. Table 1 presents the average latency for the initial saccades in each of the three conditions (no distractor, same hemifield and different hemifield) for both the older and younger adults. Indeed, there was a main effect of condition, $F(2, 44) = 8.70, p = .0001$, suggesting that subjects were distracted by the colour singleton. There was no interaction between condition and subject group, $F(2, 44) = 1.01, p > .35$, suggesting that any age-related increases in distractibility are not manifested in saccadic latency. Indeed, younger and older subjects had faster saccade latencies to the target when there was no distractor present compared with when it was either in the same hemifield, younger subjects: $t(12) = 2.63, p < .05$; older subjects: $t(12) = 2.34, p < .05$, or different hemifield as the target, younger subjects: $t(12) = 4.51, p = .0001$; older subjects: $t(12) = 3.69, p < .01$.

Table 1. Latency (in milliseconds) for the initial saccades in the no-distractor, same-hemifield and different-hemifield conditions for both the older and younger adults

		Cueing condition		
Group		No distractor	Same hemifield	Different hemifield
Older adults	Mean latency	291	306	307
	Std. error	22	26	24
Younger adults	Mean latency	274	303	290
	Std. error	16	26	16

In the same/different hemifield conditions, there is a distractor present in the visual display. For the different-hemifield condition, attention is directed away from the location of the distractor by virtue of the precue, whereas in the same-hemifield condition, the precue does not direct attention away from the location of the distractor. To examine whether the predictive cue can modulate distraction by directing attention towards the location of the target and away from the distractor, comparisons were made between saccadic latencies for the same- versus different-hemifield conditions. There was no difference in saccade latencies when a colour singleton was presented in the same- versus different hemifield, for either the younger subjects, $t(12) = -1.17$, $p > .25$, or the older subjects, $t(12) = 0.04$, $p > .9$). Thus, there was no evidence of modulation of distraction on saccadic latency.

Saccadic error

Modulation of distraction was also assessed by examining the proportion of trials for which subjects landed within 2° of the target (see Table 2). Age-related increases in distractibility would be manifested as a difference in saccadic error for older versus younger adults. There was a significant effect of subject group, $F(1, 22) = 55.91$, $p = .0001$, with younger subjects having a greater proportion of trials for which the saccade landed within 2° of the saccade target.

Table 2. Proportion of trials for which the initial saccade landed within 2° of the target in the no-distractor, same-hemifield and different-hemifield conditions for both the older adult younger adults

		Cueing condition		
Group		No distractor	Same hemifield	Different hemifield
Older adults	Mean accuracy	0.44	0.26	0.41
	Std. error	0.04	0.03	0.04
Younger adults	Mean accuracy	0.85	0.51	0.79
	Std. error	0.03	0.04	0.03

Younger subjects were more accurate than older subjects in each of the conditions; no singleton, $t(12) = 7.64$, $p = .0001$; same hemifield, $t(12) = 4.67$, $p = .0001$; different hemifield, $t(12) = 7.74$, $p = .0001$. Thus, although older subjects made saccades just as fast as younger adults, the saccades of older adults were less accurate for fixating the target, for all conditions.

There was a main effect of condition on accuracy, $F(2, 44) = 92.17$, $p = .0001$; subjects were more accurate in the no-singleton compared with the same- and different hemifield conditions. The interaction between subject group and condition was also significant, $F(2, 44) = 8.1$; $p = .0001$). Younger subjects were more accurate for the no-singleton compared with the same-hemifield condition, $t(12) = 10.55$; $p = .0001$. Likewise, the older adults had a greater proportion of saccades land within 2° of the saccade target for the no-singleton compared with the same-hemifield condition, $t(12) = 5.04$, $p = .0001$. Younger subjects were more accurate for the different- compared with the same-hemifield condition, $t(12) = 8.66$, $p = .0001$, demonstrating the effectiveness of the cue in reducing distractibility; however, although performance was similar, the presence of the cue did not bring performance back to baseline levels as evidenced by a significant difference between performance in the no-singleton and different-hemifield conditions, $t(12) = 2.85$, $p < .05$. Older subjects were also more accurate in the different-versus same-hemifield condition, $t(12) = 6.93$, $p = .0001$. Performance in the different-hemifield condition returned saccadic accuracy to baseline levels for older adults; there was no difference between no-singleton and different-hemifield conditions, $t(12) = 1.35$, $p = .2$; see Fig. 2). The significant interaction

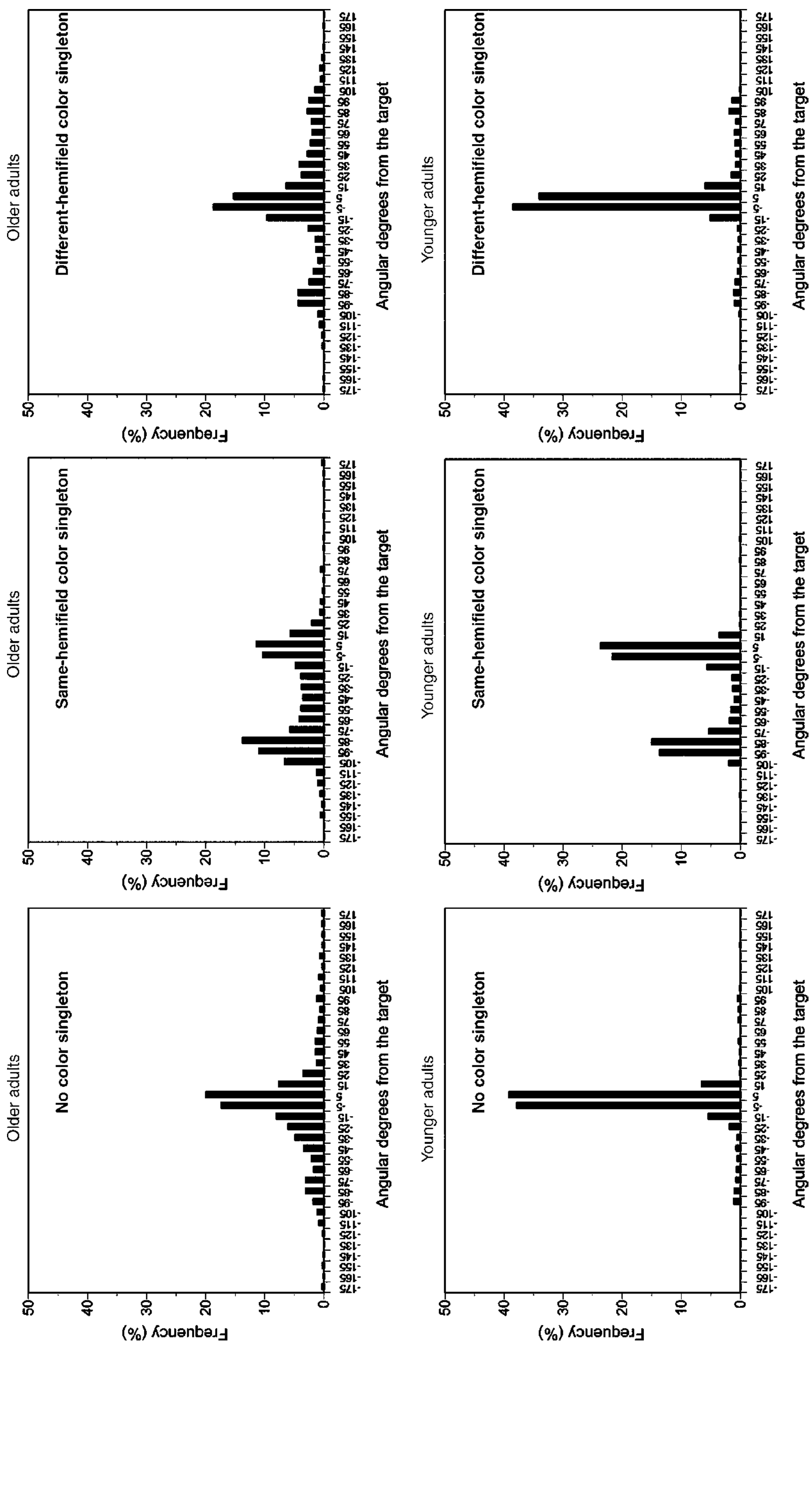

Figure 2. Frequency distributions for the saccadic end-points relative to the target in the *no-singleton* (left), *same-hemifield* (centre) and *different-hemifield* (right) conditions. Saccadic end-points are defined in terms of angular deviation from the line between central fixation and the target. Data for the older adults are shown in the top row; data for the younger subjects are presented in the bottom row.

between subject group and condition appears to be driven by the sharper decline in performance in the same-hemifield condition compared with the other conditions for the younger subjects compared with the older subjects (although performance for the older subjects may be approaching floor levels and thus not allowing similar declines to be observed; see Table 2).

Further examination of the frequency distribution in Fig. 2 shows that for the same-hemifield colour singleton, there are two clusters of saccade responses for both the younger and the older subjects: the target and the colour singleton. There was no difference between the subject groups for the proportion of trials in which the initial saccade landed on the distractor rather than the target (within 2°) when a distractor was present; $F(1, 22) < 1$; $p > .35$, and there was no interaction between subject group and condition, $F(1, 22) = 3.05$; $p = .10$.

However, older adults also appeared to saccade between the target and the colour singleton location, suggesting that they may be relying on the predictive information from the cue to generate a saccade irrespective of the impending actual target location. We examined this more formally by looking at the amount of error, in terms of visual angle, over all trials (see Table 3 for means and standard errors).

Table 3. Saccadic error relative to the target (in degrees of visual angle) for the initial saccades in the no-distractor, same-hemifield and different-hemifield conditions for both the older and younger adults

		Cueing condition		
Group		No distractor	Same hemifield	Different hemifield
Older adults	Mean error (degrees)	4.62	6.69	5.15
	Std. error	0.30	0.29	0.31
Younger adults	Mean error (degrees)	1.98	5.03	2.38
	Std. error	0.21	0.37	0.18

There was a main effect for subject group, $F(1, 22) = 99.85$, 49.59, $p < .001$, and a significant interaction between condition and subject group for error distance, $F(2, 44) = 4.79$, $p = .01$). While the error was larger for the older compared with younger subjects on all of the conditions; no-singleton: $t(12) = 7.22$, $p = .0001$; same hemifield $t(12) = 3.52$, $p < .01$; different hemifield $t(12) = 7.70$, $p = .0001$, the interaction was probably driven by a larger difference between the subject groups on the no-singleton and different-hemifield conditions (see Table 3 for means and standard errors). Combined with the findings of rates of anticipatory saccades, these results suggest that older adults may have been generating saccades based on cue information alone.

Discussion

Consistent with previous findings on oculomotor capture, younger and older adults were distracted by the colour singleton, as revealed by increased saccade latencies and decrease in saccade accuracy when the distractor was present (Kramer *et al.*, 1999). Saccade latencies to the target were shorter than saccades directed to a stimulus other than the target. This finding is opposite to that of Van Zoest, Donke, and Theeuwes (2004) in which the latencies of saccades to the distractor were shorter than those to the target. This is probably due to the precue in the current paradigm; perhaps the directing of attention to the hemifield in which the target appeared allowed for faster saccadic latencies to the target (Cavegn, 1996; Fischer & Weber, 1996). Weber, Durr, and Fischer (1998) demonstrated in a pro- and anti-saccade paradigm, a valid precue elicited orienting to the correct spatial location of the eye movement response, resulting in a decrease in saccadic latency and a decrease in errors.

Older adults were less accurate than younger adults, across all conditions, similar to previous work (Kramer *et al.*, 2000). Any interactions that were observed between age and condition were not due to an age-related increase in distractibility, but rather, due to a larger decline in performance for younger adults when the distractor was presented in the same hemifield. Older adults did not show as dramatic a decline in saccadic accuracy when the target and distractor were presented in the same hemifield, probably because performance levels were already approaching floor performance.

Distraction was modulated for both the younger and older adults, such that there were a greater proportion of trials for which saccades landed within 2° of the target location when the distractor was located in the uncued hemisphere versus the cued hemisphere. Thus, although the distance between the target and distractor was equal in both the same- and different-hemifield conditions, subjects were able to use the cue to minimize distraction and direct saccades towards the target when the target and distractor were in opposing hemispheres. These findings demonstrate that cueing subjects to multiple potential target locations can reduce interference from distractors, similar to previous work in which the exact target location was cued (e.g. Madden, 1983). However, the fact that the cueing of a general target location can modulate interference suggests that the directing of attention to a potential target location, in the absence of a programmed goal-directed eye movement, is enough to reduce interference from distractors. Indeed, previous work has suggested that attention may be deployed to multiple locations, and in particular, may be deployed to multiple saccade targets (Kowler, Anderson, Dosher, & Blaser, 1995; Godijn & Theeuwes, 2003).

Alternatively, these findings may suggest that, with a general precue, multiple goal-directed eye movements are programmed in parallel, one of which is executed upon display onset. This latter explanation may be consistent with the competitive integration model as advanced by Godijn and Theeuwes (2002b). Using an oculomotor capture paradigm in which subjects had to direct their eyes to a colour singleton, Godijn and Theeuwes found that saccade latencies to a target were longer when a distractor was present versus not present; suggesting that an endogenous eye movement to the target and an exogenous eye movement to the distractor were being programmed within the same system, rather than being programmed independently with the execution of whichever eye movement programme was completed first (independent horse race model). As Godijn and Theeuwes note, the competitive integration model can be generalized to account for paradigms in which multiple eye movements programmes may compete; in this case, multiple endogenous eye movement programmes may be in competition given that the possible locations of where the target can appear are known to the subject.

The information provided by the cue allowed older adults to compensate for distraction, and even bring performance back to that of the baseline, no-singleton condition. This finding is consistent with other lines of research suggesting cognitive performance in ageing may be preserved to the extent that there is external support that can direct the required action (e.g. Craik, 1986), and that expertise (i.e. knowledge structure) may be used as a compensatory strategy against cognitive slowing and interference (e.g. Ericsson & Charness, 1994; Mireles & Charness, 2002).

In general, older adults were less accurate than younger adults, even when no distractor was present. Moreover, older adults made more anticipatory saccades compared with younger adults, which is consistent with accounts that older adults may have problems with inhibitory processing and/or with keeping an active goal representation in mind (e.g. Hasher & Zacks, 1988; Colcombe *et al.*, 2003). Perhaps, older adults were using information from the cue alone to generate saccades. This finding converges with work from Salthouse (1984) that demonstrated that experienced typists compensate for age-related decline in processing speed by anticipating upcoming characters further ahead than their younger counterparts. While reliance on the cue allowed older adults to compensate for distraction in this particular laboratory-based paradigm, the generalizability or adaptiveness of compensation is still in question, and should be the focus of future work. Thus, while external information may be used to guide responses, the current work suggests that this modulation may cause other important information to be under-used by older adults.

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