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Capture of Attention by New Motion in Young and Older Adults

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Recent research has shown that newly introduced motion in a scene captures attention in young adults. Prior research has been mixed in terms of possible age-related differences in the allocation of visual attention, and it remains unclear whether new motion has a similar influence on visual attention in older adults. In the present study, we directly compared the capture of attention by new motion in young and older adults. The results suggest that new motion has a similar influence on visual attention in older adults as compared with young adults and that the mechanisms underlying attentional capture by motion are preserved with adult aging. We discuss the findings within the context of our present understanding of visual attention and aging.

Key Words: Attentional capture—New motion—Visual attention.

AT any given moment, we are faced with countless sources of visual information. To analyze and process all of the potential input is beyond the capacities of the human brain. Therefore, it is necessary to select particular elements from our visual environment for further processing. Visual attention represents the mechanism by which this selection process occurs. Effective shifting and allocation of visual attention allows us to effectively navigate and interact with our environment.

The choice of which elements to process further can be influenced by both our goals and expectations (termed *goal-directed attention*) as well as by characteristics inherent in the visual stimuli themselves (termed *stimulus-driven attention*; see Jonides, 1981; Posner & Cohen, 1984). For example, when shopping in a large superstore, we may be looking for a particular brand of product (goal-directed attention) but our attention may also be drawn to the generic product next to the flashing blue light (stimulus-driven attention). Another distinction between goal-directed and stimulus-driven attention relates to the time duration during which subsequent processing at the attended location is enhanced.

Goal-directed attention can be maintained somewhat indefinitely, thus providing a sustained opportunity for enhanced processing of stimuli at the attended location (Jonides, 1981; Müller & Rabbit, 1989). In contrast, the perceptual benefits associated with stimulus-driven shifts of attention appear to be much shorter lived. Immediately following an attention-capturing stimulus (e.g., a flash of light), stimuli presented at the same location receive enhanced processing. Within as little as 300 ms after the attention-capturing event, however, stimuli presented at the location are actually at a relative disadvantage. This latter phenomenon is called ''inhibition of return'' (IOR) and is believed to reflect the fact that individuals are inhibited from returning their attention to a previously attended location (Posner & Cohen, 1984).

Salient visual stimuli vary in the extent to which they can be said to capture attention in a stimulus-driven fashion. For example, color singletons appear to attract attention, but only when they are consistent with the observer's goals or attentional set (Folk, Remington, & Wright, 1994; Jonides & Yantis, 1988). In contrast, the abrupt onset of a visual stimulus appears to capture attention in a truly stimulus-driven fashion insomuch as it influences attention regardless of the person's goals and intentions (Christ & Abrams, 2006a; Neo & Chua, 2006). Recently, Abrams and Christ (2003; 2005a) have identified another stimulus event that appears to capture attention in a bottom-up, stimulus-driven manner: the onset of motion, or ''new motion,'' in a scene. Utilizing a visual search paradigm, the researchers found that young adults were faster to respond to visual items that recently began to move than to items that remained static, items that recently stopped moving, and items that had already been moving for some time prior to target presentation. This was the case despite the fact that the target was equally likely to appear in any of the four types of items. Subsequent work suggests that new motion in the visual display continues to influence one's attentional allocation even in the presence of strong motivation to maintain attention elsewhere in the display (Christ & Abrams, 2006b). Thus, new motion appears to capture attention in a stimulus-driven fashion.

As noted above, intact attentional abilities are important for everyday functioning. Indeed, failure of this system could mean attending to irrelevant information (more so than usual) and, conversely, failing to attend to important information in a timely fashion. Within this context, it is important to elucidate what developmental changes (if any) in attentional control are associated with adult aging.

Findings from previous research studying the influence of adult aging on visual attention abilities are mixed. In general, the ability to allocate attention in either a goal-directed (in response to an indication of the likely location of a subsequent target stimulus) or stimulus-driven (in response to one of the aforementioned nonpredictive types of stimulus events) fashion appears to remain largely intact with advanced aging (Faust & Balota, 1997; Greenwood, Parasuraman, & Haxby, 1993;

Hartley, Kieley, & Slabach, 1990; Nissen & Corkin, 1985). Subtle age-related differences in the timing and extent of the allocation of attention, however, have been reported. For example, a number of studies of goal-directed attention have documented larger cue-related facilitation (reaction time, or RT, when the target appears in an uncued location minus RT when the target appears in the cued location) for older adults than for younger adults (Greenwood & Parasuraman, 1994; Greenwood et al.; Hartley et al.). Some studies of stimulus-driven attention have found a similar age-related increase in facilitation at short stimulus-onset asynchronies (SOAs; delays between the cue and target) or delayed onset or reduced IOR at longer SOAs in older adults (Castel, Chasteen, Scialfa, & Pratt, 2003; Faust & Balota; Greenwood & Parasuraman, 1994; McCrae & Abrams, 2001; Pratt & Bellomo, 1999).

Some researchers have suggested that the increased cueing effect and delayed onset of IOR may reflect an age-related difficulty in disengaging attention from a previously attended location (Castel et al., 2003; Greenwood & Parasuraman, 1994; Greenwood et al., 1993; Madden, Connelly, & Pierce, 1994). Alternatively, Greenwood and Parasuraman (2004) have postulated that an age-related decline in the ability to narrowly focus attention may underlie these findings. Yet others have argued that findings such as these may reflect age-related differences in processing speed, strategy choice, interference suppression, and/or sensory processing rather than attentional allocation per se (e.g., Gottlob & Madden, 1998, 1999; Layton, 1975; Salthouse, 2000).

Whereas a growing amount of evidence suggests that processing of motion-related information may be affected by advanced aging (Betts, Taylor, Sekuler, & Bennett, 2005; Snowden & Kavanagh, 2006; Trick & Silverman, 1991), relatively little is known regarding how such age-related changes may influence the role of motion processing in visual attention. Only a handful of past studies have been published on this topic, and they have focused solely on the ability to utilize motion-related features to direct visual search in a goal-directed fashion. For example, Kramer, Martin-Emerson, Larish, and Andersen (1996) found that older adults were just as capable as younger adults in using the presence or absence of motion to identify targets in a conjunction search task (e.g., find the moving letter X among moving letter Os and stationary letter Xs). In contrast, Folk and Lincourt (1996) reported age-related differences in the ability to use direction of motion to guide a conjunctive search (e.g., find the vertically oscillating letter X among vertically oscillating letter Os and horizontally oscillating letter Xs). Lastly, the findings of Watson and Maylor (2002) suggest that younger but not older adults are able to use motion-related information to visually mark nontargets and thereby improve visual search. Taken together, these studies indicate that older adults may experience circumscribed impairments in goal-directed attention related to motion processing. To date, however, no studies have examined possible age-related changes in the role of motion processing in stimulus-driven attention.

To the best of our knowledge, in all previous studies of stimulus-driven attention in older adults, participants' attention has been drawn to a particular spatial location by the use of a large luminance change or an abrupt onset of a new element in the display. In the present study, we attempt to extend this literature and examine the influence (if any) that increased age has on the capture of attention by newly introduced motion.[1] For this purpose, we utilized an experimental paradigm that has proven effective in the past for evaluating attentional capture by new motion in young adults (Experiment 1a from Abrams & Christ, 2003). Further, this paradigm provides the added advantage of allowing one to directly compare the attentional influence of new motion to that of other motion transients (old motion, motion offset, and no motion).

In the present experiment, we asked younger and older adults to perform a visual search task in which they located and identified a target presented along with three distracting items. Presentation of the search display was coupled with a change in the motion status of two of the items in the display: A previously static item began moving, and a previously moving item stopped. The motion status of the remaining two items in the display did not change (i.e., a previously static item remained static, and a previously moving item continued to move). Importantly, the item containing the target was equally likely to be any one of the four types of items. We considered the time needed to identify the target (i.e., response time) in each condition as evidence of the extent to which the various motion changes attracted attention.

METHODS

Participants

Twenty college-aged students (age, $M = 20$ years, $SD = 1.4$, range = 18–24; education, $M = 14$ years, $SD = 0.8$, range = 13–16; 8 men and 12 women) and 20 older adults (age, $M = 75$ years, $SD = 7.9$, range = 65–90; education, $M = 15$ years, $SD = 2.7$, range = 12–20; 8 men and 12 women) served as participants in a single 40-minute session. All participants were experimentally naïve. The younger adults received course credit in exchange for participation; the older adults received $10. No one who participated in the study reported having a history of visuoperceptual disorder (e.g., color blindness, tunnel vision), mental retardation, learning disorder, dementia, or a major medical or psychiatric disorder. Formal measures of visual acuity were not available; however, all participants reported having normal or corrected-to-normal visual acuity and no restrictions of their visual fields. Further, all older adult participants as well as the majority of young adult participants indicated that their vision had been screened by a qualified professional (optometrist or ophthalmologist) within the past year.

Apparatus and Procedure

The apparatus and procedure were identical to those we used in a previous study (Abrams & Christ, 2003). Participants were seated 34 in. (86 cm) from a 60-Hz CRT display in a dimly lit room. The sequence of events on each trial is shown in Figure 1. Each trial began with a preview display that consisted of a central fixation point and four figure-eight placeholders. Each placeholder was 2° high and 1° wide. The placeholders were randomly distributed within an imaginary 18° square centered on the central dot, with the following constraints: None of the placeholders were aligned either vertically or horizontally with each other, and no placeholder appeared within 1° of another placeholder or the central dot. (On average, the resulting distance from fixation to placeholder was approximately 6°.)

When the display initially appeared, two of the placeholders were moving along a tight circular path (2° diameter measured from the center of the placeholder) while the other two were stationary. We accomplished this motion by displaying each placeholder (and subsequently, any moving letters in the search array) for 67 ms at each of 16 evenly spaced positions along its movement path. When the moving placeholders first appeared, one was moving in a clockwise direction and the other was moving counterclockwise.

Following a 3,200-ms delay, two line segments were removed from each placeholder to reveal the search display. One of the placeholders became the letter S or H, representing the target stimulus. All remaining placeholders were replaced by distracter letters (either all Es or all Us). Participants were instructed to respond to the target's identity as quickly as possible by pressing one of two keys (i.e., the z or "/" key) on the keyboard.

Coincident with presentation of the search array, a movement transition occurred that produced four different motion conditions: One of the moving items stopped moving (motion offset); one of the previously static items began moving (new motion); one static item remained stationary (static); and one moving item continued moving (old motion). Of note, all four types of motion were present on every trial, but for convenience we will refer to a given motion condition to mean the trials on which the target appeared in the object that underwent that type of motion transient.

The search array remained visible until the participant responded. If a participant responded incorrectly, a brief tone followed by the message "wrong response" was presented. A tone and relevant message (i.e., "too early" or "too slow") was presented if a participant responded less than 300 ms after array onset or failed to respond within 3,000 ms, respectively. After each block, particpants were informed of their mean RT and number of errors.

Design

Following 24 practice trials, participants served in 288 experimental trials. Trial presentation was balanced such that the target was equally likely to appear in each of the four different types of items, the distracter letters were equally likely to be E or U, and the target letter was equally likely to be S or H. The target-to-response key mapping was counterbalanced across participants. Trial types were randomly mixed. At intervals of 48 trials, participants were given an opportunity to take a break.

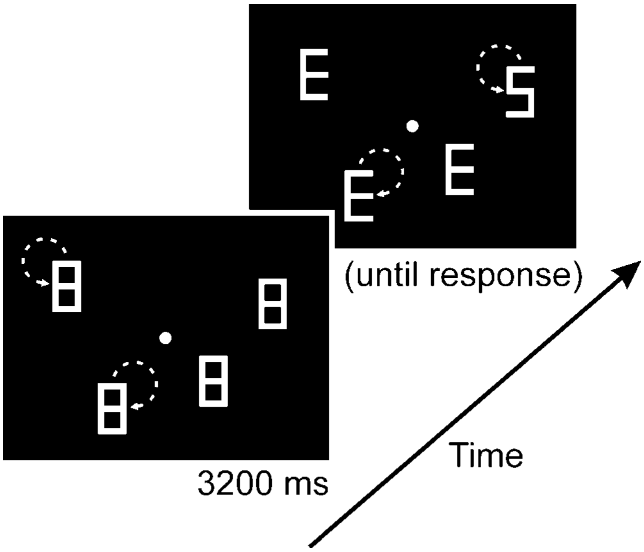

Figure 1. Sequence of events on a new motion trial.

RESULTS

Overall RT Analysis

We excluded trials on which an error occurred from the RT analysis. Mean RTs for each condition are listed in Table 1 and shown graphically in Figure 2. The data were analyzed using mixed-model analysis of variance (ANOVA), with group (young adult and older adult) as the between-subjects variable and condition (static, old motion, motion offset, and new motion) as the within-subjects variable. Overall, older adults responded slower than did young adults [$F(1, 38) = 59.6$, $MSE = 73{,}501$, $p < .001$]. A main effect of condition [$F(3, 114) = 55.2$, $MSE = 1{,}722$, $p < .001$] and an interaction between condition and group [$F(3, 114) = 6.8$, $MSE = 1{,}722$, $p < .001$] were also found.

To further elucidate the nature of the observed effects, we conducted additional 2 × 2 mixed-model ANOVAs, systematically comparing pairs of conditions (e.g., new motion vs static, new motion vs old motion, static vs motion offset, and so forth) across the two groups.

Importantly, participants in both groups were faster to respond when the target appeared in the newly moving item

Table 1. Means and Standard Deviations for Raw Scores, *z* Scores, and Error Rates

	Young Adult						Older Adult					
	Raw RT (ms)		z Score		Error Rate (%)		Raw RT (ms)		z Score		Error Rate (%)	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Static	726	85	−0.03	0.14	6.3	4.4	1068	178	0.03	0.13	5.9	3.0
Old motion	760	92	0.16	0.12	6.5	3.6	1108	190	0.14	0.13	6.6	3.9
Motion offset	753	89	0.12	0.15	6.5	4.3	1107	195	0.14	0.14	6.5	3.1
New motion	688	94	−0.25	0.15	4.0	2.3	968	140	−0.30	0.12	4.0	2.6

Note: RT = reaction time; *SD* = standard deviation.

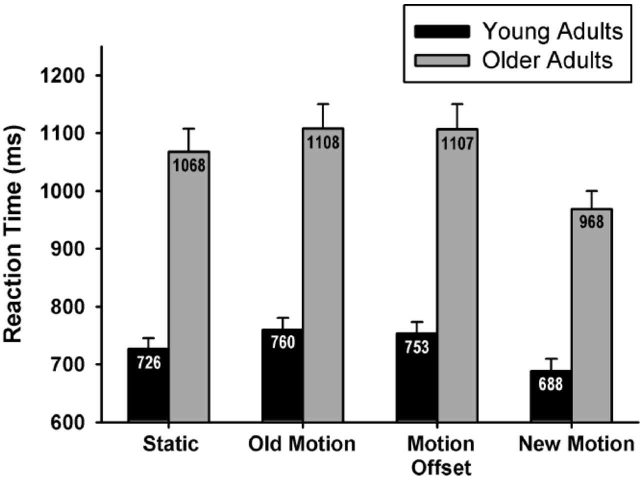

Figure 2. Mean reaction times for target identification, shown separately for each motion condition (static, old motion, motion offset, and new motion). Error bars represent standard errors of the mean.

than when it appeared in the static, old motion, or motion offset items [main effect of condition: $F(1, 38) = 68.0$, 132.1, and 74.6, respectively; $MSE = 1{,}391$, 1,681, and 2,756, respectively; $p < .001$ in all instances]. Therefore, it appears that new motion captures attention in young as well as older adults.[2] The magnitude of this effect, however, appeared to vary across groups, as evident by a significant Group × Condition interaction in each case [Group × Condition interaction: $F(1, 38) =$ 13.6, 13.7, and 9.8, respectively; $MSE = 1{,}391$, 1,681, and 2,756, respectively; $p < .005$ in all instances].

Overall, both groups were slightly faster in the static condition than they were in either the old motion or motion offset conditions [main effect of condition: $F(1, 38) = 15.5$ and 13.7, respectively; $MSE = 1{,}729$ and 1,557, respectively; $p < .001$ in both instances]. However, these effects appeared to be relatively comparable across groups [Group × Condition interaction: $F(1, 38) < 1$ in both instances; $MSE = 1{,}729$ and 1,557, respectively; $p > .05$ in both instances]. There was no observable difference between the old motion and motion offset conditions for either group [main effect of condition: $F(1, 38) < 1$, $MSE = 1{,}221$, $p > .05$; Group × Condition interaction: $F(1, 38) < 1$, $MSE = 1{,}221$, $p > .05$].

Analysis of Speed-Corrected Data

As one can see in Figure 2, the magnitude of the RT benefit for the new motion condition is noticeably larger for the older adults (static RT – new motion RT = 100 ms) than it is for their younger counterparts (static RT – new motion RT = 38 ms). Upon initial glance, one might be tempted to interpret this pattern of results as evidence that new motion captures attention more effectively (or to a greater extent) in older adults than it does in younger adults. As noted above, however, older adults were also slower to respond overall. Slowed processing speed (Cerella, 1990; Salthouse, 2000) may have contributed to both the slower response latencies and the larger RT effect observed in older adults. Consequently, the raw RT values do not provide an accurate estimate of the relative magnitude of the influence that new motion has on visual attention in older adults as compared with young adults. Transformation of the RT values into speed-corrected z scores may allow for better comparison.

In order to control for individual differences in processing speed, we standardized the RTs within participants, with the result being an overall mean transformed RT of 0 for each participant (e.g., Christ, White, Mandernach, & Keys, 2001; Faust et al., 1999; Pratt, Abrams, & Chasteen, 1997).[3] The computed standard scores for each condition are listed in Table 1.

To evaluate the possibility of age-related differences in the magnitude of attentional effect for new motion above and beyond processing speed differences, we repeated the previously described analyses using the computed z scores. As one might expect, the overall 2 (young adult and older adult) × 4 (static, old motion, motion offset, and new motion) mixed-model ANOVA continued to yield a robust effect of condition [$F(3, 114) = 61.53$, $MSE = .025$, $p < .001$]. Of note, there was also no evidence of an interaction between condition and group [$F(3, 114) < 1$, $MSE = .025$, $p > .05$], suggesting that, after we controlled for individual differences in processing speed, young and older adults' performance was comparable across the four experimental conditions.

We observed a similar pattern for the 2 × 2 ANOVAs comparing new motion to each of the other three conditions (static, old motion, and motion offset) across the two age groups. A main effect of condition was found [$F(1, 38) = 87.1$, 160.4, and 89.6, respectively; $MSE = 0.017$, 0.023, and 0.036, respectively; $p < .001$ in all instances]. Most relevant, there was no evidence of an interaction between condition and group [$F(1, 38) = 3.3$, 0.3, and 0.8, respectively; $MSE = 0.017$, 0.023, and 0.036, respectively; $p > .05$ in all instances], suggesting that, after we controlled for individual differences in processing speed, new motion has a similar influence on visual attention in young and older adults.

Regression Analysis of RT Data

As detailed herein, following transformation of raw RTs to z scores, the Condition × Group interaction for new motion as compared with the static condition was no longer statistically significant. This is consistent with the notion that observed group differences were related to general processing speed. It is worth noting, however, that the magnitude of the new motion effect appeared to remain slightly greater for the older adult group than for the young adult group (static z score – new motion z score = 0.33 and 0.22 for older and young adults, respectively). This trend may have further approached significance with an increase in sample size.

To further evaluate the possible contribution of additional age-related factors to new motion RT above and beyond general processing speed, we conducted a supplementary analysis using a hierarchical regression approach. RT in the new motion condition served as the dependent variable. We included RT in the static condition in the first step of the statistical model. Group (young and older) was then entered into the second step of the model. By utilizing this approach, we were able to partial out variability in new motion RT related to processing speed (as reflected by RT in the static condition) and identify any remaining variance attributable to other group-related factors.

The findings were clear. After accounting for performance in the static condition [$R^2 = 0.94$, $F(1,38) = 622.8$, $p < .001$], we found that group (young and older) made little or no contribution to RT in the new motion condition [$\Delta R^2 = 0.0001$, $F(1, 37) < 1$, $p > .05$]. We observed similar results when controlling for old motion RT or motion offset RT instead of static condition RT [$\Delta R^2 < 0.004$, $F(1, 37) < 1.5$, $p > .05$ in both instances].

Taken together with results of the *z*-score analysis, these findings provide converging evidence for the notion that attentional capture by new motion is comparable for young and older adults, and the observed group differences in the magnitude of the RT benefit afforded to new motion were related primarily to individual differences in processing speed.

Analysis of Error Rates

Mean error rates for each condition are listed in Table 1. A 2 (young and older) × 4 (static, old motion, motion offset, and new motion) mixed-model ANOVA revealed a main effect of condition [$F(3, 114) = 7.77$, $MSE = 7.85$, $p < .001$], but no evidence of a main effect of group [$F(1, 38) < 1$, $MSE = 24.68$, $p > .05$] or an interaction between group and condition [$F(3, 114) < 1$, $MSE = 7.85$, $p > .05$]. As one can see in Table 1, both groups made fewer errors in the new motion condition (mean error rate = 4.0%) as compared with the other three conditions (mean error rate across other conditions = 6.4%).

DISCUSSION

In the present study, we found evidence for attentional capture by new motion in young and older adults, suggesting that the neurocognitive mechanisms underlying this attentional phenomenon likely are preserved with adult aging.[4] An analysis of raw RTs revealed that the RT benefit for new motion was greater in older adults than it was for younger adults. Upon further analysis, however, it was apparent that this difference was related to group differences in processing speed and not visual attention per se. After utilizing *z*-score transformation as well as linear regression to control for individual differences in processing speed, we found no evidence of a difference between young and older adults in the influence that new motion has on visual attention.

The present findings highlight a potential dissociation in age-related changes in the role of motion processing in goal-driven and stimulus-driven attention. As noted earlier, the ability to utilize motion-related information to direct visual search in a goal-directed fashion appears to decline with age (Folk & Lincourt, 1996; Watson & Maylor, 2002; for an exception, see Kramer et al., 1996). In contrast, the current results suggest that motion processing as it relates to stimulus-driven attention is relatively preserved with adult aging.

Broadly speaking, the present results are also consistent with previous research demonstrating intact stimulus-driven capture of attention in older adults (e.g., Faust & Balota, 1997; Greenwood et al., 1993; Hartley et al., 1990). They extend these past findings to include the capture of attention by new motion, a previously unstudied topic in the adult aging literature. The present findings are also consistent with our current understanding of the neural substrates underlying stimulus-driven shifts of visual attention. Specifically, posterior cortical regions (e.g., posterior parietal cortex) and subcortical regions (e.g., superior colliculus) are believed to play an integral role in stimulus-driven shifts of attention (for review, see Posner & Petersen, 1990). These regions appear to be less susceptible to age-related neurophysiological changes than more anterior brain regions (e.g., prefrontal cortex; see, e.g., Raz, 2000; Raz et al., 2005; Resnick, Pham, Kraut, Zonderman, & Davatzikos, 2003). Therefore, one might predict that stimulus-driven attentional mechanisms (and other abilities relying on more posterior brain regions) would show less age-related impairment compared to those abilities (e.g., interference suppression) relying on more severely affected, anterior regions, which is consistent with the present results.

As we noted earlier, a number of past studies utilizing other types of attention-capturing stimulus events (e.g., abrupt onset) have documented larger cueing effects for older as compared with younger adults (e.g., Castel et al., 2003; Faust & Balota, 1997; Pratt & Bellomo, 1999). These differences appear to persist even after researchers account for age-related differences in processing speed (Faust & Balota; Pratt & Bellomo). In contrast, the magnitude of the cueing effect elicited by new motion in the present study was equivalent for young and older adults. A number of possible explanations for this discrepancy exist. One possibility is that the neurocognitive processes underlying attentional capture by new motion are relatively spared with advanced age and are distinct from those processes underlying attentional capture by other stimulus events. Another possibility is that age-related differences in cueing effects do exist for new motion; however, the SOA utilized in the present study (i.e., 0 ms) was not optimal for detecting such differences. Additional research is necessary to fully discern the nature of this discrepancy.

In closing, the present study demonstrated that new motion captures attention in both young and older adults. From an ecological standpoint, it has been postulated that new motion may capture attention because it signals the likely presence of another living being, thus representing a potential predator or prey (Abrams & Christ, 2003; Franconeri & Simons, 2003). Given that the identification of such dangers or food sources remains important (or increases in importance) as one ages, it would be best if new motion continued to have an influence on attention throughout the life span (as it apparently does).

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REFERENCES

Abrams, R., & Christ, S. (2003). Motion onset captures attention. *Psychological Science, 14,* 427–432.

Abrams, R., & Christ, S. (2005a). Onset but not offset of irrelevant motion disrupts inhibition of return. *Perception & Psychophysics, 67,* 1460–1467.

Abrams, R., & Christ, S. (2005b). The onset of receding motion captures attention: Comment on Franconeri & Simons. *Perception & Psychophysics, 67,* 219–223.

Betts, L., Taylor, C., Sekuler, A., & Bennett, P. (2005). Aging reduces center-surround antagonism in visual motion processing. *Neuron, 45,* 361–366.

Castel, A., Chasteen, A., Scialfa, C., & Pratt, J. (2003). Adult age differences in the time course of inhibition of return. *Journal of Gerontology: Psychological Sciences, 58B,* 256–259.

Cerella, J. (1990). Aging and information processing rates in the elderly. In J. Birren & K. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 332–340). New York: Academic.

Christ, S., & Abrams, R. (2006a). Abrupt onsets cannot be ignored. *Psychonomic Bulletin & Review, 13,* 875–880.

Christ, S., & Abrams, R. (2006b). Automatic capture of attention by motion onset. *Manuscript submitted for publication.*

Christ, S., & Abrams, R. (in press). The attentional influence of new objects and new motion. *Journal of Vision.*

Christ, S., White, D., Mandernach, T., & Keys, B. (2001). Inhibitory control across the life-span. *Developmental Neuropsychology, 20,* 653–669.

de Fockert, J., Rees, G., Frith, C., & Lavie, N. (2004). Neural correlates of attentional capture in visual search. *Journal of Cognitive Neuroscience, 16,* 751–759.

Faust, M., & Balota, D. (1997). Inhibition of return and visuospatial attention in healthy older adults and individuals with dementia of the Alzheimer type. *Neuropsychology, 11,* 13–29.

Faust, M., Balota, D., Spieler, D., & Ferraro, F. (1999). Individual differences in information-processing rate and amount: Implications for group differences in response latency. *Psychological Bulletin, 125,* 777–799.

Folk, C., & Lincourt, A. (1996). The effects of age on guided conjunction search. *Experimental Aging Research, 22,* 99–118.

Folk, C., Remington, R., & Wright, J. (1994). The structure of attentional control: Contingent attentional capture by apparent motion, abrupt onset, and color. *Journal of Experimental Psychology: Human Perception & Performance, 20,* 317–329.

Franconeri, S., & Simons, D. (2003). Moving and looming stimuli capture attention. *Perception & Psychophysics, 65,* 999–1010.

Franconeri, S., & Simons, D. (2005). The dynamic events that capture visual attention: A reply to Abrams and Christ (2005). *Perception & Psychophysics, 67,* 962–966.

Gottlob, L., & Madden, D. (1998). Time course of allocation of visual attention after equating for sensory differences: An age-related perspective. *Psychology and Aging, 13,* 138–149.

Gottlob, L., & Madden, D. (1999). Age differences in the strategic allocation of visual attention. *Journal of Gerontology: Psychological Sciences, 54B,* P165–P172.

Greenwood, P., & Parasuraman, R. (1994). Attentional disengagement deficit in nondemented elderly over 75 years of age. *Aging and Cognition, 1,* 188–202.

Greenwood, P., & Parasuraman, R. (2004). The scaling of spatial attention in visual search and its modification in healthy aging. *Perception & Psychophysics, 66,* 3–22.

Greenwood, P., Parasuraman, R., & Haxby, J. (1993). Changes in visuospatial attention over the adult lifespan. *Neuropsychologia, 31,* 471–485.

Hartley, A., Kieley, J., & Slabach, E. (1990). Age differences and similarities in the effects of cues and prompts. *Journal of Experimental Psychology: Human Perception & Performance, 16,* 523–537.

Hillstrom, A., & Yantis, S. (1994). Visual motion and attentional capture. *Perception & Psychophysics, 55,* 399–411.

Jonides, J. (1981). Voluntary versus automatic movements of the the mind's eye. In J. Long & A. Baddeley (Eds.), *Attention and Performance IX* (pp. 197–203). Hillsdale, NJ: Lawrence Erlbaum.

Jonides, J., & Yantis, S. (1988). Uniqueness of abrupt visual onset in capturing attention. *Perception & Psychophysics, 43,* 346–354.

Kramer, A., Martin-Emerson, R., Larish, J., & Andersen, G. (1996). Aging and filtering by movement in visual search. *Journal of Gerontology: Psychological Sciences, 51B,* 201–216.

Layton, B. (1975). Perceptual noise and aging. *Psychological Bulletin, 82,* 875–883.

Madden, D., Connelly, S., & Pierce, T. (1994). Adult age differences in shifting focused attention. *Psychology and Aging, 9,* 528–538.

McCrae, C., & Abrams, R. (2001). Age-related differences in object- and location-based inhibition of return of attention. *Psychology & Aging, 16,* 437–449.

Müller, H., & Rabbit, P. (1989). Reflexive and voluntary orienting of visual attention: Time course of activation and resistance to interruption. *Journal of Experimental Psychology: Human Perception & Performance, 15,* 315–330.

Neo, G., & Chua, F. (2006). Capturing focused attention. *Perception & Psychophysics, 68,* 1286–1296.

Nissen, M., & Corkin, S. (1985). Effectiveness of attentional cueing in older and younger adults. *Journal of Gerontology, 40,* 185–191.

Posner, M., & Cohen, Y. (1984). Components of visual orienting. In H. Bouma & D. Bouwhuis (Eds.), *Attention and performance X* (pp. 531–556). Hillsdale, NJ: Erlbaum.

Posner, M., & Petersen, S. (1990). The attention system of the human brain. *Annual Review of Neuroscience, 13,* 25–42.

Pratt, J., Abrams, R., & Chasteen, A. (1997). Initiation and inhibition of saccadic eye movements in younger and older adults: An analysis of the gap effect. *The Journals of Gerontology: Series B, Psychological Sciences and Social Sciences, 52B,* 103–107.

Pratt, J., & Bellomo, C. (1999). Attentional capture in younger and older adults. *Aging, Neuropsychology, and Cognition, 6,* 19–31.

Raz, N. (2000). Aging of the brain and its impact on cognitive performance: Integration of structural and functional findings. In F. Craik & T. Salthouse (Eds.), *Handbook of Aging and Cognition II* (pp. 1–90). Mahwah, NJ: Erlbaum.

Raz, N., Lindenberger, U., Rodrigue, K., Kennedy, K., Head, D., Williamson, A., et al. (2005). Regional brain changes in aging healthy adults: General trends, individual differences and modifiers. *Cerebral Cortex, 15,* 1674–1689.

Resnick, S., Pham, D., Kraut, M., Zonderman, A., & Davatzikos, C. (2003). Longitudinal magnetic resonance imaging studies of older adults: A shrinking brain. *Journal of Neuroscience, 23,* 3295–3301.

Salthouse, T. (2000). Aging and measures of processing speed. *Biological Psychology, 54,* 35–54.

Snowden, R., & Kavanagh, E. (2006). Motion perception in the ageing visual system: Minimum motion, motion coherence, and speed discrimination thresholds. *Perception, 35,* 9–24.

Trick, G., & Silverman, S. (1991). Visual sensitivity to motion: Age-related changes and deficits in senile dementia of the Alzheimer type. *Neurology, 41,* 1437–1440.

Watson, D., & Maylor, E. (2002). Aging and visual marking: Selective deficits for moving stimuli. *Psychology and Aging, 17,* 321–339.

Wolfe, J. (1998). Visual search. In H. Pashler (Ed.), *Attention* (pp. 13–73). London: University College London Press.

Yantis, S., & Egeth, H. (1999). On the distinction between visual salience and stimulus-driven attentional capture. *Journal of Experimental Psychology: Human Perception & Performance, 25,* 661–676.

Yantis, S., & Jonides, J. (1990). Abrupt visual onsets and selective attention: Voluntary versus automatic allocation. *Journal of Experimental Psychology: Human Perception & Performance, 16,* 121–134.

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END NOTES

1. A number of recent studies (Abrams & Christ, 2003, 2005a, 2005b; Christ & Abrams, 2006b; Franconeri & Simons, 2003) have found evidence that the introduction of new motion to a previously existing object captures attention in young adults. It remains unclear, however, whether new items that are in motion when they first appear are afforded a similar attentional advantage (as compared with new static items; see Christ & Abrams, in press; Franconeri & Simons, 2005; Hillstrom & Yantis, 1994; Yantis & Egeth, 1999). In the present study, we have chosen to focus on the more well-established phenomenon of attentional capture by new motion in an existing object.
2. The present results are consistent with the notion that new motion attracted attention, thus leading to enhanced target identification in both young and older adults. In addition, past research with young adults has found that attentional capture by

new motion appears to be automatic in that it leads to efficient visual search (Abrams & Christ, 2003) and it cannot be avoided (Christ & Abrams, 2006b), thus fulfilling the load-insensitivity criterion and intentionality criterion for automatic processes outlined by Yantis and Jonides (1990). Future research on this topic may provide further insight into the extent to which this phenomenon can be said to be truly automatic in older adults as well.

It is also worth noting that, in isolation, the present study does not rule out the possibility that old motion or motion offset might capture attention relative to the static condition; however, it is very unlikely given that previous research (Abrams & Christ, 2003, 2005a; Franconeri & Simons, 2005) directly comparing these conditions (in the absence of new motion) found no evidence for attentional capture by either of the aforementioned motion transients (old motion and motion offset).

3. We have chosen not to utilize a proportional transformation in light of arguments (e.g., Faust, Balota, Spieler, & Ferraro, 1999) that proportional data transformations do not fully control for age-related differences in processing speed. An assumption in making such transformations is that the function relating the processing speed of two groups is linear and has an intercept of zero. This is often not the case.

4. Interpretation of the present data as evidence of attentional capture by new motion is entirely consistent with the treatment of this topic within the existing literature on visual attention (e.g., Wolfe, 1998; Yantis & Jonides, 1990). It remains important, however, to keep in mind that the RT difference observed between the new motion and static conditions may reflect a combination of (a) enhanced RT to the new motion item as well as (b) slowed RT to the static item associated with secondary processes such as disengaging, shifting, and reengaging attention (e.g., Posner & Cohen, 1984) or interference suppression (e.g., de Fockert, Rees, Frith, & Lavie, 2004). Within this context, the present finding of no age-related differences (unrelated to processing speed) is consistent with the notion that all such mechanisms involved in attentional capture by new motion are largely intact.