Center for Accessibility and Safety for an Aging Population

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RESEARCH FINAL REPORT

The Impact of Red Light Running Camera Flashes on Younger and Older Drivers' Attention and Oculomotor Control

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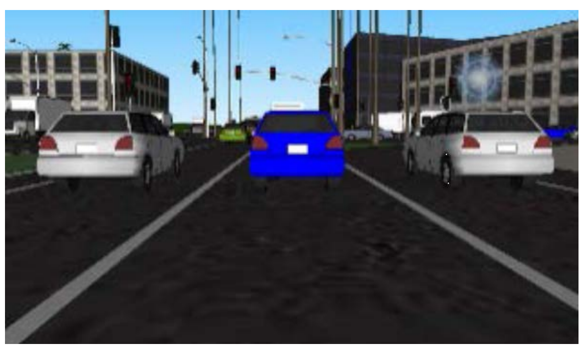

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Final Report

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16. Abstract

Recent empirical evidence suggests that the flashes associated with red light running cameras (RLRC) distract younger drivers, pulling attention away from relevant roadway information and delaying visual processing. Considering the perceptual and attentional declines that occur with age, older drivers may be especially susceptible to the distracting effects of RLRC flashes, particularly in situations in which the RLRC flash is highly salient (a bright flash at night). The current study examined age and situational differences in RLRC flash capture. Two experiments utilized both covert (inhibition of return) and overt (eye movement) indices of attention in order to explore potential age differences in the distracting effects of RLRC flashes. Salience of the flash was manipulated by varying its luminance and contrast with respect to the background of the driving scene (either day or night scenes). Results suggest that simulated RLRC flashes capture observers' attention, but, surprisingly, no age differences in attention capture were found with either covert or overt markers of attention. Findings inform future work that will examine how the distracting effects of RLRC flashes influence driving behavior.

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Abstract

Recent empirical evidence suggests that the flashes associated with red light running cameras (RLRC) distract younger drivers, pulling attention away from relevant roadway information and delaying visual processing. Considering the perceptual and attentional declines that occur with age, older drivers may be especially susceptible to the distracting effects of RLRC flashes, particularly in situations in which the RLRC flash is highly salient (a bright flash at night). The current study examined age and situational differences in RLRC flash capture. Two experiments utilized both covert (inhibition of return) and overt (eye movement) indices of attention in order to explore potential age differences in the distracting effects of RLRC flashes. Salience of the flash was manipulated by varying its luminance and contrast with respect to the background of the driving scene (either day or night scenes). Results suggest that simulated RLRC flashes capture observers' attention, but, surprisingly, no age differences in attention capture were found with either covert or overt markers of attention. Findings inform future work that will examine how the distracting effects of RLRC flashes influence driving behavior.

Chapter 1 Introduction

Driver distraction is currently a topic of great interest to researchers, lawmakers, and the general public. National Highway Traffic Safety Administration (NHTSA) reported that in 2009 distracted driving was a contributing cause in 17% of all crashes. While much research has focused on how cell phones and in-vehicle technologies create distraction and impair driving performance (e.g., Caird, Johnston, Willness, Asbridge, & Steel, 2014), approximately 25% of all distracted driving crashes result from distraction *outside* of the vehicle (Trezise et al., 2006). In these cases, presumably irrelevant information pulled the driver's attention away from critical driving-relevant information, impairing the processing of this information and resulting in a crash.

The flash that accompanies Red Light Running Cameras (RLRCs) has anecdotally been reported as one type of distraction capable of pulling attention away from the driving task (Townsend, 2011; Tuss, 2012). In addition to these anecdotal claims, initial empirical evidence suggests that RLRC flashes capture attention in simulated driving scenes (Sall, Wright, & Boot, 2014). These anecdotal claims and initial empirical evidence suggesting RLRC pull attention away from relevant roadway information are further supported by a large number of studies of visual attention demonstrating that a transient luminance change is one of the most reliable means to capture attention and the eyes. This literature also suggests that attention capture is automatic and unavoidable, and that it can delay the processing of task-relevant information by over 100 milliseconds (e.g., Boot, Kramer, & Peterson, 2005). In addition to these attentional effects, it is also reasonable (especially at night) to expect the bright flash of RLRCs to impair perceptual processing. These impairments might include the creation of distracting afterimages and the loss of dark adaptation.

In order to examine if RLRC flashes capture attention, Sall and colleagues (2014) used two basic signatures of attention capture: inhibition of return (IOR; Posner & Cohen, 1984; see Klein, 2000 for review) and eye movements (Butler, Zacks, & Henderson, 1999; Kramer, Hahn, Irwin, & Theeuwes, 2000; Munoz, Broughton Goldring, & Armstrong, 1998). IOR is a classic effect that occurs when an irrelevant distractor captures attention prior to the presentation of a target. As in Sall et al. (2014), when capture by the distractor (i.e., RLRC flash) occurs close in time (150 ms) and in the same location as the target (i.e., brake lamp event), attention is pulled to the target location and detection of the target is facilitated. When capture occurs at the target location, but there is a longer period of time (550 ms) before the presentation of the target, attention has already left and inhibited the location of the upcoming target. Accordingly, detection of the target is delayed. In addition to eliciting IOR, RLRC flashes in simulated roadway scenes captured the eyes and delayed subsequent eye movements to the target brake event. If RLRC flashes are indeed distracting, older adults may be especially susceptible to their effects. First, a number of studies indicate that in some contexts older adults have poorer attentional and eye movement control, and that compared to younger adults they may be more easily distracted by salient but irrelevant information (Butler et al., 1999; Kramer et al., 2000; Munoz et al., 1998; Sweeney, Rosano, Berman, & Luna, 2001; Weeks & Hasher, 2014). Second, advancing age is associated with increased susceptibility to glare (Allen & Vos, 1967; Gray & Regan, 2007) and increased time to dark adapt once dark adaptation has been lost (Jackson, Owsley, & McGwin, 1999). Third, any distracting effect of RLRC flashes would occur at locations older drivers already demonstrate differential risk (intersections). Approximately half of all crashes older adults experience occur at intersections compared to about a third for younger adults (Choi, 2010).

While initial empirical evidence suggests that simulated RLRC flashes capture younger observers' attention in daytime scenes, currently no studies exist that compare the distracting effects of these flashes across situational factors and age groups. The goal of the current study is to determine if older adults are a population more susceptible to the distracting effects of RLRC flashes, especially in situations when this flash is likely to be highly salient (e.g., a bright flash at night). As the current study is interested in 1) confirming the distracting effects of RLRC flashes on observer's attention and oculomotor control, 2) examining age and situational differences in the distracting effects of these flashes, and 3) further categorizing age differences in IOR through examining differences in this classic attention effect with a more complex and familiar scene, two experiments were conducted. Both experiments utilized a variant of the RLRC paradigm developed by Sall and colleagues (2014). Experiment 1 used the behavioral version of this paradigm with the goal of confirming the effects of RLRC flashes on observers' (younger, middle-aged, and older) covert attention and further categorizing age differences in IOR. Experiment 2 used an eye-tracking version of the paradigm and reduced the flash prevalence in order to further examine age and situational factors' influence on RLRC flash capture, particularly with respect to oculomotor control. The results of these experiments have applied implications in that they will inform future work looking at how differential costs in RLRC flash distraction translate to driving behavior.

Chapter 2 Experiment 1

Experiment 1 was similar to the first experiment of Sall et al. (2014). Younger, middle-age, and older observers viewed both day and night driving scenes and manually responded when a brake event occurred. A RLRC flash that varied in intensity was presented on some trials prior to the target brake event. Consistent with Sall et al. (2014) and studies of IOR using more basic paradigms (Posner & Cohen, 1984), we expected observers to be faster to respond to the target event on trials in which the cue (RLRC flash) occurred in the same location as the target, and the onset between the presentation of the cue and the presentation of the target was short (150 ms stimulus onset asynchrony; SOA). On the contrary, we expected observers to be slower to respond to the target event on trials in which the cue (RLRC flash) occurred in the same location as the target, and SOA between the presentation of the cue and target was long (550 ms). Furthermore, as IOR is an index of the location of observers' attention, we expected older age groups to be more susceptible to the distracting effects of RLRC flashes and demonstrate increased IOR relative to younger adults, particularly in night scenes when the flash was most intense.

2.1 Method

2.1.1 Participants

Forty-eight participants were recruited from the Tallahassee, FL area. Sixteen of these participants were Florida State University students (9 females; *M* = 19.4 years of age, *SD* = 1.2, Range = 18 – 21 years of age) who participated in exchange for course credit. The remaining 32 participants consisted of 16 middle-age (10 females, *M* = 57.3 years of age, *SD* = 5.0, Range = 50 – 64 years of age) and 16 older adults (7 females, *M* = 72.6 years of age, *SD* = 5.0, Range = 66 – 81 years of age) who participants in exchange for fifteen dollars. All participants reported normal or corrected-to-normal color vision. All participants reported having a valid US or Canadian driver's license.

2.1.2 Apparatus and Stimuli

See figure 2.1 for an example of the displays participants viewed. (Hi-res version of figure is available at http://figshare.com/s/2a4c66d4898411e4810306ec4b8d1f61.)

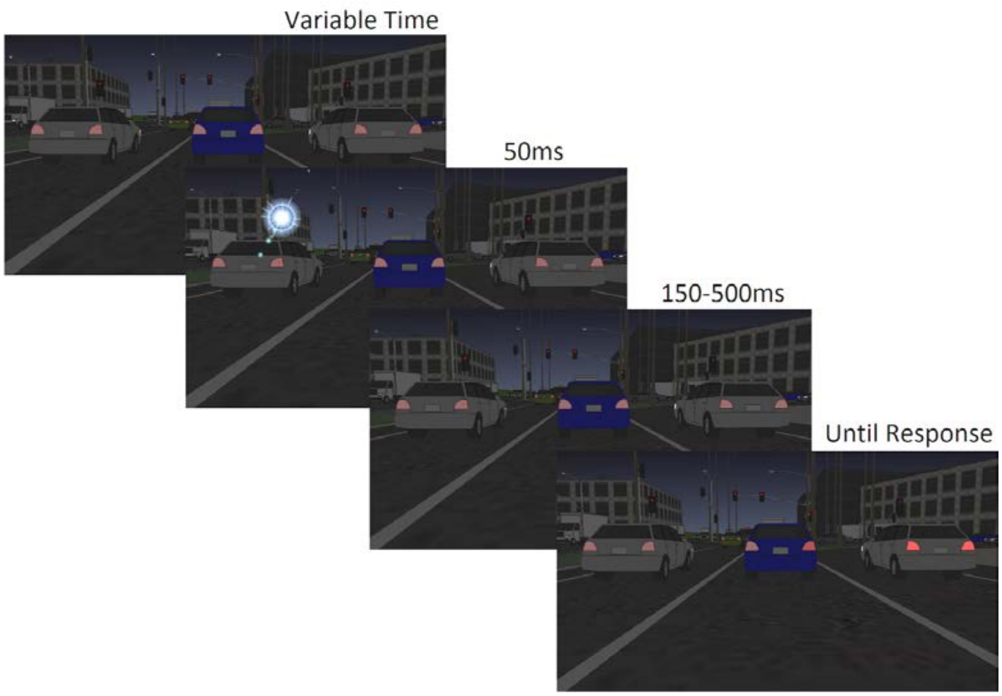

Figure 2.1 RLRC Paradigm

Displays were presented on an 18-inch color CRT monitor with a resolution of 1024 × 768 pixels and 85 Hz screen refresh rate. Participants viewed the displays from a distance of approximately 65 cm in a dark room and provided responses on a standard keyboard. At this distance, the display subtended an area of approximately 17 degrees by 31 degrees of visual angle. Stimuli consisted of images of simulated signalized intersection from the point of view of the driver created with Google SketchUp and were presented with the OpenSesame platform (Mathôt, Schreij, & Theeuwes, 2012). Mirroring the design of a typical spatial cueing paradigm, three cars were arranged horizontally. The brake lights of the car on the left or the right could onset, and a simulated RLRC flash could occur either to the left or right of the intersection.

2.1.3 Procedure

Participants were instructed to press the spacebar as soon as they detected the onset of the brake lights of one of the cars, and were warned of the flash and told to ignore it. In order to examine the role of situational factors in RLRC flash distraction, day and night scenes each with three levels of flash intensity (low, medium, high) were used (see fig. 2.2). (Hi-res version of figure is available at http://figshare.com/s/470b884c899611e48adc06ec4b8d1f61.)

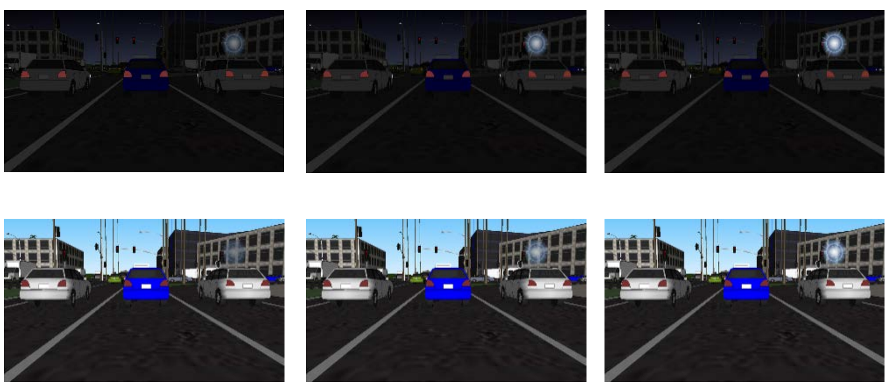

Figure 2.2 Scene and Flash Intensity Examples

Two levels of SOA (150 or 550 ms) were also used. Participants completed all blocks of a specific scene type (e.g., day) before moving on to the blocks with the other scene type (e.g., night). The onset of the flash (with a duration of 50 ms) could occur equally often 150 ms or 550 ms before the illumination of one of the cars' brake lights. Congruent trials (trials on which the flash and brake lights occurred on the same side of the display) and incongruent trials (trials on which the flash and brake lights occurred on the opposite side of the display) were equally likely to occur. Flash intensity was also counterbalanced within-subjects; whereas scene order was counterbalanced between-subjects. On 50% of all trials, no flash occurred (neutral). Overall, participants completed 48 practice trials, followed by 480 (240 day, 240 night) experimental trials that took no longer than 60 minutes to complete. Participants were instructed always to keep their eyes on the center car and to detect the target with their peripheral vision. After response, the next trial (onset of the next flash) began automatically after 1000 ms, 1500 ms, or 2000 ms. Participants were given feedback about their speed and were given the opportunity to take a break after every 48 trials.

2.2 Results

2.2.1 Trial Exclusion

Trials with response times less than 100 ms were considered anticipatory and were not included in analyses, and trials with response times greater than 1 s were considered to be the result of inattention and were also excluded. This resulted in less than 5% of trials being trimmed.

2.2.2 IOR

In order to examine whether the simulated RLRC flash captured attention, IOR effect scores were calculated as the difference in response time (RT) on trials in which the RLRC flash occurred on the same side as the target brake event compared to trials in in which the RLRC flash occurred on the opposite side of the target brake event (congruent RT – incongruent RT trials). If the RLRC flash captured attention, we would expect negative scores (facilitation rather than inhibition) at the early SOA and positive scores at the late SOA. These scores were entered into an analysis of variance with SOA (150 and 550), scene type (day and night), and flash intensity (low, medium, and high) as within-subjects factors and age group (younger, middle, and older) as between-subjects factors. Replicating Sall et al. (2014), a main effect for SOA was found, $F(1, 45) = 34.45$, $p < .001$. This main effect suggests that the time course of the flash modulates observers' RT to the brake event. To further examine whether the presence of the flash resulted in capture at each of the time intervals, the IOR effect scores were compared to a value of zero. At the early SOA, observers were faster to respond to the brake event when the flash was congruent with the brake event compared to when it was incongruent with the brake event, $t(47) = -7.12$, $p < .001$ (diff = -23 ms, $SD = 23$ ms). That is, even though the flash was irrelevant and participants were told to ignore it, it still captured attention. On the contrary, at the late SOA, observers were slower to respond to the brake event when the flash was congruent with the brake event compared to when it was incongruent with the brake event, $t(47) = 2.32$, $p < .05$ (diff = 12 ms, $SD = 35$ ms). However, neither flash intensity nor scene type interacted with SOA, $F(2, 90) = .43$, $p = .65$ and $F(1, 45) = .98$, $p = .33$ respectively, and no three-way interaction between flash intensity, scene type, and SOA was found, $F(2, 90) = .83$, $p = .44$, suggesting the distracting effects were consistent across situational factors. In sum, the simulated RLRC flash captured attention. The flash facilitated faster responses when it appeared closer in time to the target as attention never had time to disengage away from the target location. On the contrary, the flash slowed responses when there was a longer delay between the flash and target, as attention had marked and left the target location, inhibiting attention's return.

2.2.3 Age Differences in IOR

Of primary interest were age differences in the capture effect. That is, older adults may be more susceptible to the distracting effects of RLRC flashes, particularly in night scenes and when the flash was more intense, due to their reduced inhibitory processes. We did not find evidence to support this hypothesis (see fig 2.3).

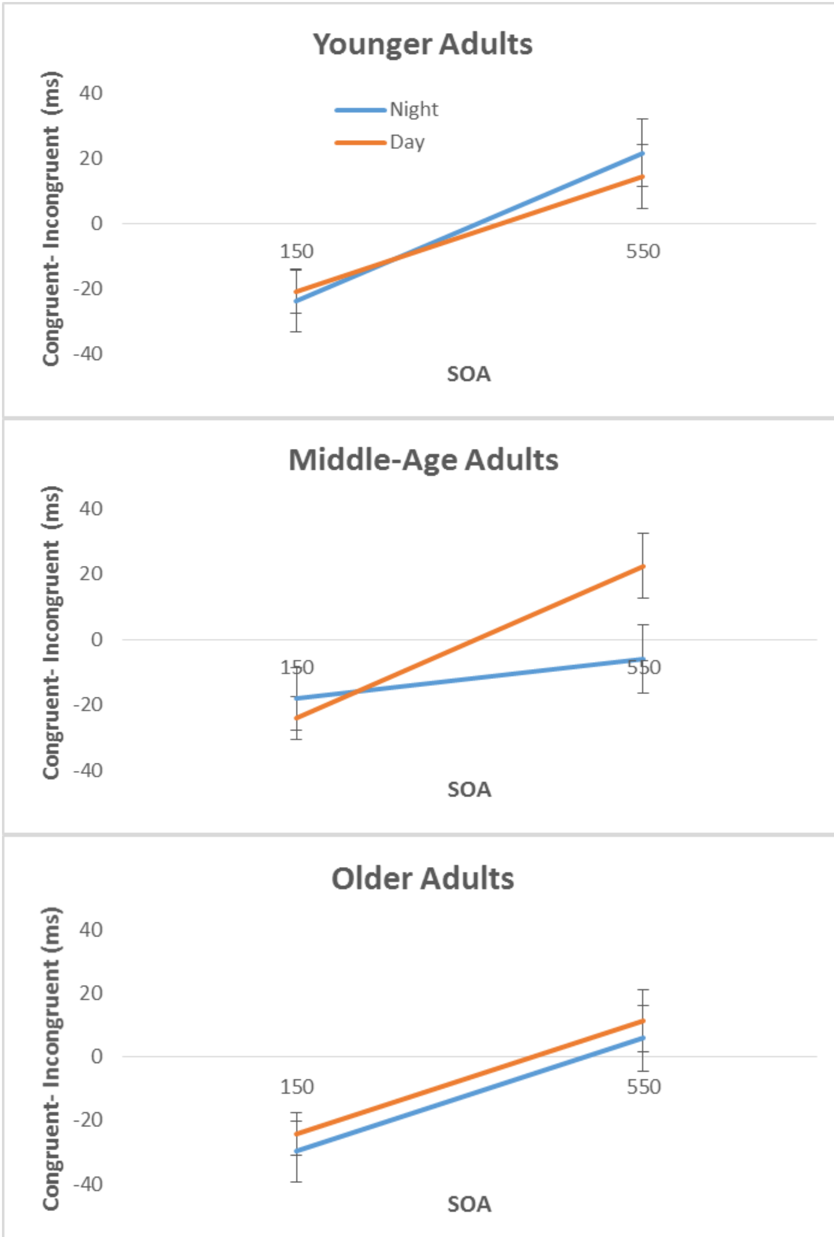

Figure 2.3 Age Differences in IOR

In fact, a trend for a three-way age group, SOA, and scene type interaction, $F(2, 45) = 2.74$, $p = .08$ was found that was primarily reflective of middle-age adults not exhibiting the typical pattern of IOR in night scenes. The authors are cautious in interpreting this trend, however, as it is not intuitive why middle-age adults would not exhibit capture in the night scenes when both younger and older adults do. Furthermore, age group did not interact with SOA, $F(2, 45) = .28$, $p = .76$., suggesting that the simulated RLRC flash was not differentially distracting to any of the age groups (see fig. 2.3), and situational factors did not reveal any age differences in the distracting effects of the RLRC flashes (all *p*s > .26). That is, while the RLRC on average captured observers' attention, age, situational factors, or an interaction between the two factors does not appear to be associated with increased susceptibility to capture.

2.3 Discussion

The IOR effects observed in Experiment 1 were consistent with those observed in Sall et al. (2014). The simulated RLRC flash influenced attention at both the early SOA and late SOA. The former resulted in a facilitation of faster response time to the target event. Specifically, the flash pulled attention to the target location, and the target appeared before the disengagement of attention from that location, speeding response to the target. The capture of attention at the late SOA resulted in inhibition. That is, the RLRC flash pulled attention to the target location, but attention left this location and inhibited itself from returning. This slowed attention's eventual return to the target location. While we expected older age groups to be more susceptible to the distracting effects of RLRC flashes, particularly in instances in which the flash was more physically salient (e.g., at night when the flash was the brightest), we did not find any evidence that the flash differentially captured middle-age or older adults' attention.

Despite a great deal of evidence suggesting that older adults are more susceptible to salient distractions (Butler, Zacks, & Henderson, 1999; Kramer, Hahn, Irwin, & Theeuwes, 2000; Munoz, Broughton Goldring, & Armstrong, 1998; Sweeney, Rosano, Berman, & Luna, 2001), no differences in RLRC flash capture across age groups were observed in Experiment 1. It is possible that older adults' familiarity with the driving scenes used in the study may have attenuated any differences in capture; however, this is difficult to conclude considering the consistency in our findings and other studies examining age differences in location-based IOR effects (Faust & Balota, 1997; Hartley & Kieley, 1995; Langley, Gayzur, Saville, Morlock, & Bagne, 2011; McCrae & Abrams, 2001). Accordingly, Experiment 2 more directly examined age and situational differences in RLRC flash capture through the use of an oculomotor variant of the RLRC paradigm (see Experiment 3 of Sall et al., 2014).

Chapter 3 Experiment 2

Experiment 2 was similar to Experiment 1; however, instead of using manual reaction time and IOR as a covert index of attention, saccadic reaction time (SRT) and eye movement direction were used to overtly examine age and situational differences in the distracting effects of RLRC flashes. Eye movements are frequently used as a marker of attention (Boot et al, 2005; Theeuwes, Kramer, Hahn, & Irwin, 1998) because the vast majority of the time, observers are attending to the location at which they are looking (for evidence of the eyes as a valid indicator of attention's location see Butler et al., 1999; Kramer et al., 2000; Moore & Fallah, 2001; Munoz et al., 1998). In order to more accurately simulate the prevalence of these flashes in realistic driving situations (drivers do not encounter this flash at most intersections), an initial block of trials was added to habituate participants to no flash conditions. Also, flash prevalence was reduced so that only 10% of trials contained the distracting event. The overt index of attention (eye movements) and simulation of real-world conditions was expected to maximize power to detect age differences (if they exist).

3.1 Method

3.1.1 Participants

Forty-eight participants from the Tallahassee, FL area completed the eye tracking task[1]. Sixteen of these participants were Florida State University students (8 females; *M* = 19.4 years of age, *SD* = .9, Range = 18 – 21 years of age) who participated in exchange for course credit. The remaining 32 participants consisted of 16 middle-age (9 females, *M* = 56.8 years of age, *SD* = 6.5, Range = 38 – 64 years of age) and 16 older adults (7 females, *M* = 70.1 years of age, *SD* =

[1] Incomplete data from 14 participants (1 middle-age and 13 older) were excluded from analyses due to eye tracker calibration issues. These issues are not uncommon with remote eyetrackers with an older population (see Bowling, Lindsay, Smith, & Storok, 2014; Störmer, Heekeren, & Lindenberger, 2011 for other examples of data loss due to eye-tracker issues).

4.6, Range = 65 – 80 years of age) who participants in exchange for fifteen dollars. All participants reported normal or corrected-to-normal color vision. All participants reported having a valid US driver's license. Finally, all participants in this experiment had not participated in Experiment 1.

3.1.2 Apparatus and Stimuli

Participants were presented with the same intersection images using the same software as Experiment 1. Eye movements were recorded using an SR Research Eyelink 1000 eye tracker (SR Research), which recorded the position of the participants' right eye every 1 ms. An eye movement was classified as a saccade if its distance surpassed 0.2° and acceleration reached 9500 deg/s^2.

3.1.3 Procedure

Procedure was the same as Experiment 1 except for the reported changes. Participants were instructed to look at a fixation point (white on a black background) at the center of the screen and press a key on the keyboard to start each trial. Once the button was pressed, participants were presented with the intersection scene. This fixation point was in the same location as the center car. For the first 56 trials, no flash occurred. These trials were not analyzed. Following this initial block of trials, the experimental blocks began. In these blocks, the flash (low, medium, and high) occurred on 10% of trials, and they were always anti-predictive of the target location. Only the 150 ms SOA was used.   Participants were asked to maintain fixation on the center car until the brake lights of one of the cars were lit. They were instructed to look at this car as quickly as possible. Once more, participants were told a flash might appear but to ignore it. Participants completed 480 (240 day, 240 night) experimental trials. Trials consisted of 432 neutral trials, in which no flash occurred, and 48 flash (16 high intensity, 16 medium intensity, and 16 low intensity) trials. Flash intensity and location (left or right) were counterbalanced within-subjects. Scene order (day or night) were counterbalanced between-subjects.

3.2 Results

Areas of interest were defined by dividing the screen into two regions, one encompassing the area to the left of fixation and one compassing the area to the right. SRTs were calculated for eye movements that were directed to the same side of the display as the brake lights (accurate saccades). SRTs were defined as the time between the onset of the brake lights and the initiation of an eye movement in that direction. SRTs less than 80 ms were considered anticipatory and were not included in analyses.

3.2.1 Saccade Latency

We first examined evidence of oculomotor capture through an analysis of SRTs. Considering that the flash was always anti-predictive of the target's location, we focused on the difference between incongruent (flash) and neutral (no flash) trials. If the flash did capture attention, we would expected SRTs to be slower when it was present compared to when it was absent. SRTs associated with incorrect eye movements directed to the wrong side of the display were excluded. SRTs were entered into an ANOVA with scene type (night and day) and flash condition (high, medium, low, and none) as within-participant factors and age (younger, middle, or older) as a between-subjects factor. A main effect for flash condition was found, $F(3, 126) = 27.88$, $p < .001$. Replicating Sall et al. (2014), observers were slower to saccade to the brake event when a flash occurred compared to when no flash occurred, $t(44)$[2] $= 8.19$, $p < .001$ (diff = 48 ms, $SD = 40$ ms) (see fig. 3.1). In fact, the flash significantly delayed eye movements at each

[2] The lower degrees of freedom in some of these comparisons reflects that a total of three participants (one in each age group) failed to make an accurate saccade in at least one of the flash intensity conditions. This is further evidence of the flashes' tendency to disrupt oculomotor control.

flash intensity compared to when no flash occurred: low, $t(44) = 5.55$, $p < .001$ (diff = 42 ms, *SD* = 51 ms); medium, $t(44) = 7.03$, $p < .001$ (diff = 46 ms, *SD* = 44 ms); high, $t(44) = 8.65$, $p < .001$ (diff = 57 ms, *SD* = 44 ms).

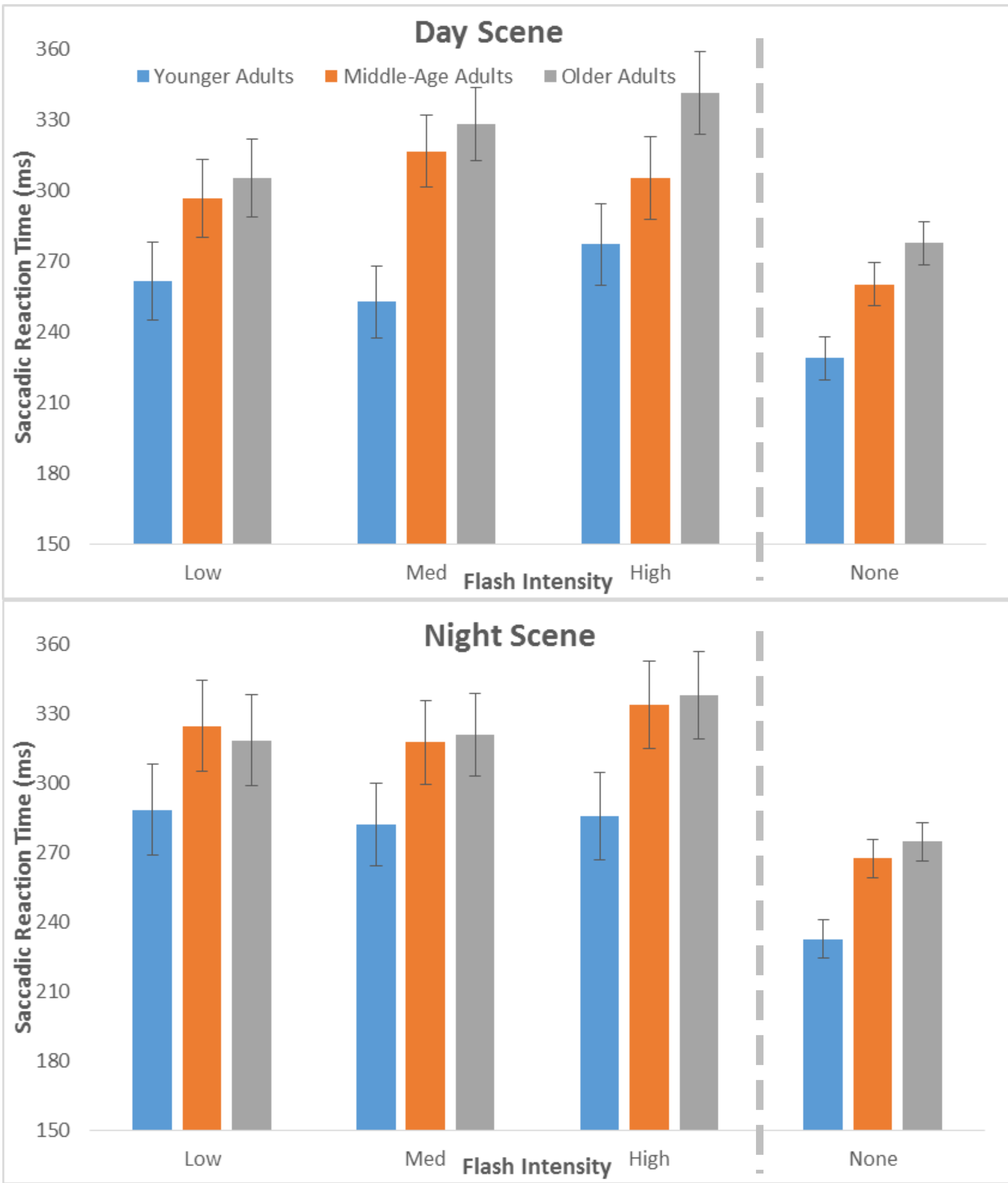

Figure 3.1 Age and Situational Differences in Saccade Latency

There was also some evidence that flash intensity differentially delayed eye movements, as the high intensity flash resulted in slower eye movements to the target brake event compared to the low intensity flash, $t(44) = 2.04$, $p < .05$ (diff =14 ms, SD = 47 ms). However, the high intensity flash did not differentially delay eye movements compared to the medium intensity, and the medium intensity flash did not differentially delay eye movements compared to the low intensity (all *p*s >.11). Furthermore, no main effect of scene type, $F(1, 42) = 2.44$, $p = .13$, or interaction between scene type and flash condition was found, $F(3, 126) = 1.26$, $p = .29$. In sum, the flash delayed the processing of task-relevant information with little evidence that a brighter flash resulted in a larger delay. This suggests that once a flash is above some threshold value, it will capture attention and intensity increases above that threshold are not attracting attention any more effectively.

3.2.2 Age Differences in Saccade Latency

Once again of primary interest were age differences in capture of the simulated RLRC flash, specifically capture of the eyes. If the older age groups are more susceptible to the distracting effects of these flashes, we would expect a greater delay initiating a saccade to the target for these age groups compared to the delay observed for younger age groups (Sall et al., 2014). Surprisingly, the ANOVA described above failed to reveal significant two-way age group and flash condition or age group and scene type interactions, $F(6, 126) = .56$, $p = .76$ and $F(2, 42) = .65$, p = .53, respectively. Furthermore, no significant three-way interaction among age group, scene type, and flash condition was found, $F(6, 126) = .68$, $p = .67$. See figure 3.1. This suggests that the older age groups were no more susceptible to the distracting effects of the RLRC flashes, even in situations in which these flashes were highly salient (a bright flash at night).

It is important to note that the older age groups SRTs were still slower overall compared to younger adults, as evident by the main effect of age, $F(2, 42) = 5.07$, $p = .01$. Specifically, middle-aged adults (M = 303 ms, SD = 53 ms) were slower overall in their eye-movements compared to younger adults (M = 264 ms, SD = 37 ms), $t(28) = 2.35$, $p = .03$, and older adults (M = 313 ms, SD = 43 ms) were slower than younger adults, $t(28) = 3.36$, $p < .01$. No difference in SRTs were found between older adults and middle-aged adults, $t(28) = .58$, $p = .57$, suggesting these two groups were very similar in terms of their oculomotor control. These overall delays may reflect a shift in strategy in the older age groups, whereas the older age groups delay their allocation of attention to target relevant stimuli in order to minimize the distracting effects of simulated RLRC flashes. A SRT bin analysis later will examine this post-hoc hypothesis.

3.2.3 Saccade Direction

Next, we examined whether the simulated RLRC flash caused observers to make an erroneous eye movement to the flashed side rather than the side containing the brake event and if situational factors or age increased these erroneous eye movements. Since the flash was always anti-predictive of the target's location, we once again focused on the difference between incongruent (flash) trials and neutral (no flash) trials. If the flash did capture attention, we would expect observers to be less accurate initiating a saccade to the target on trials in which the flash was present compared to when it was absent. Eye movement accuracy data were entered into an ANOVA with scene type (night and day) and flash condition (high, medium, low, and none) as within-subjects factors and age (younger, middle, or older) as a between-subjects factor. Once again, a main effect for flash condition was found, $F(3, 135) = 60.22$, $p < .001$. Replicating Sall et al. (2014), observers were less accurate on trials in which a flash occurred compared to trials in which no flash occurred, $t(47) = -11.47$, $p < .001$ (diff = -29%, SD = 17%) (see fig. 3.2).

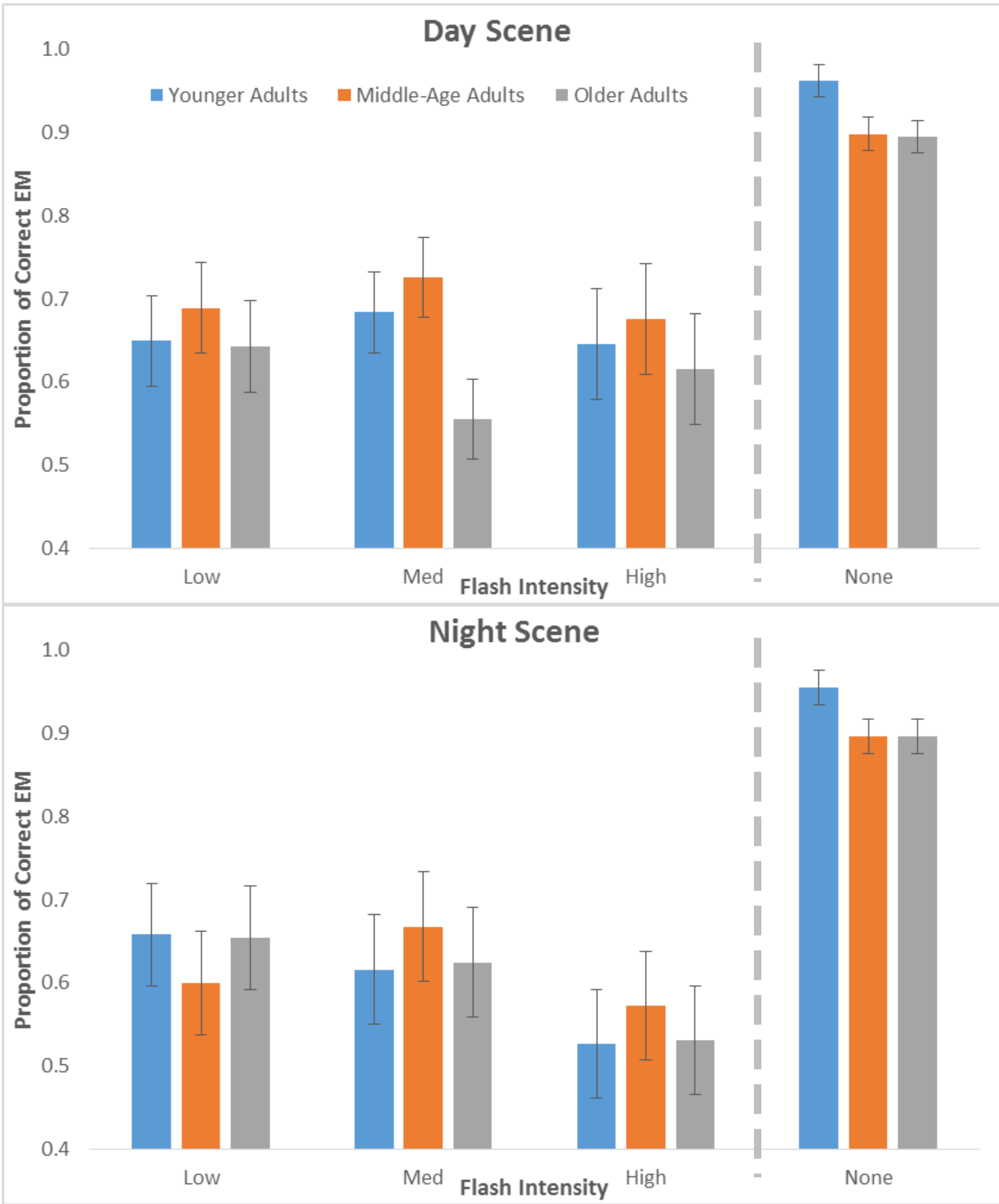

Figure 3.2 Age and Situational Differences in Saccade Direction

In fact, the flash resulted in less accurate eye movements at each flash intensity compared to when no flash occurred: low, $t(47) = -10.43$, $p < .001$ (diff = -27%, SD = 18%); medium, $t(47) = -9.59$, $p < .001$ (diff = -27%, SD = 20%); high, $t(47) = -10.15$, $p < .001$ (diff = -32%, SD = 22%). There was also some evidence that flash intensity differentially resulted in less accurate eye movements, as the high intensity flash resulted in less accurate eye movements than the medium intensity flash, $t(47) = -2.20$, $p = <.05$ (diff = -5%, SD = 16%), and the low intensity flash, $t(47) = -2.06$, $p <.05$ (diff = -5%, SD = 18%). However, the medium intensity flash did not differentially result in less accurate eye movements than the low intensity flash, $t(47) = -2.06$, $p = .89$. The above ANOVA also revealed a main effect of scene type, $F(1, 45) = 4.22$, $p = .046$, and a trend for an interaction between scene type and flash condition, $F(3, 135) = 2.45$, $p = .07$. Observers were overall less accurate initiating a saccade to the target in night scenes compared to day scenes, $t(47) = -2.05$, $p = <.05$ (diff = -4%, SD = 12%). This main effect is in line with the trend for the interaction suggesting that the higher intensity flash was more distracting in the night scenes than the day scenes. See figure 3.2. In sum, the simulated RLRC flash attracted the eyes away from task-relevant information, with more salient flashes disrupting oculomotor control to a greater extent.

3.2.4 Age Differences in Saccade Direction

Across all observers, the simulated RLRC flash captured the eyes, but were the older age groups more susceptible to the distracting effects of these flashes and more likely to execute an erroneous saccade in their presence? Surprisingly, the older age groups were not differentially distracted by the simulated RLRC flash, as the ANOVA described above did not reveal a flash condition and age interaction, $F(6, 135) = .95$, $p = .46$. Even in conditions in which the flash was expected to be particularly salient (at night or at night with a high intensity flash), the older age groups appear to be just as accurate as younger adults in the presence of this distractor, as no scene and age interaction, $F(2, 45) = 1.09$, $p = .34$, or three-way flash condition, scene, and age interaction were found, $F(6, 135) = .73$, $p = .63$. See figure 3.2. Consistent with the SRT analysis, older age groups were no more susceptible to the distracting effects of the RLRC flashes, even in situations in which these flashes were highly salient.

Chapter 4 General Discussion

The current study examined age and situational differences in RLRC flash capture with both covert (IOR) and overt (saccadic latency and direction) indices. Consistent with previous research, across both indices simulated RLRC flashes distract observers, pulling attention away from relevant roadway information and delaying visual processing. While results of Experiment 2 do suggest that both physical (flash intensity) and relative salience (contrast with background) of the flash can sometimes determine the extent of capture, across both experiments, no age differences in capture were found even in the most salient of situations (a bright flash at night).

Based on the current study and Sall et al. (2014), the findings of basic research that examine IOR appear to be robust even when using stimuli in which observers are more familiar. Still, primary task experience may be the key factor in determining the decrement in performance older adults' exhibit compared to younger adults. Experiment 2 used a paradigm very similar to other basic attention paradigms that have shown robust age differences in attention capture, with the only difference is that the current study's paradigm being it is more complex and familiar. This change may have been enough to minimize age differences across groups. Future work should directly compare attention capture across both basic and more familiar paradigms with the same age group samples in order to confirm how primary task experience may affect these processes.

Even if those with more driving experience are able to minimize the distracting effects of RLRC flashes, these flashes are still significantly distracting to observers across all ages. It is important to note, though, that providing so many trials in a study likely induced compensatory processes in older adults and, as a result, may underestimate the decrement in performance for this age group. In driving situations, RLRC flashes at night are rarely encountered by older adults, as this age group tends to drive less at night. As such, older adults would have little benefit from their superior conceptual processing (Amer & Hasher, 2014) and would be more likely to be impaired by the flash. Nevertheless, the current study highlights the importance of future work that examines how the perceptual and attentional effects associated with these flashes influence driving behavior (brake response time and rear-end collisions). It is also important to note that the perceptual and attentional decrements induced by RLRC flashes would come at a critical period of time of the driving task. For example, consider a driver approaching a red light as the RLRC fires. If at this time attention is allocated to an irrelevant location (the flash) instead of the car immediately in front of their own, this may significantly increase the likelihood of a rear-end collision (a change in accident patterns is often observed after the installation of RLRCs; Erike, 2009; Høye, 2013). In a worst-case scenario, the flash might occur as a result of a misfire (false alarm) as an older driver is navigating the intersection at full speed or while the driver is attempting to turn left (given that older adults are already more susceptible to left-turn crashes). If negative effects on driver behavior are observed, the next step would be to investigate ways in which this effect might be reduced or eliminated.

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