Article ▸ Retinal Defocus and Eye Dominance Effect on Eye-Hand Reaction Time

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ABSTRACT

Purpose: To study the effect of retinal defocus and sighting eye dominance on simple eye-hand reaction time in young visually-normal adults.

Methods: Sixteen visually-normal individuals participated in a simple eye-hand reaction time test with different amounts of spherical and astigmatic retinal defocus introduced binocularly in the spectacle plane (plano to +10.00D sphere and +0.50 to +2.00D cyl). Reaction time was assessed under binocular-viewing conditions using the RT-2S Simple Reaction Time Tester. The test target color and size simulated a conventional traffic signal. In addition, sighting eye dominance testing was performed monocularly with different defocus amounts introduced before each eye on a subset of eight subjects.

Results: There was no significant effect (p>0.05) of either spherical or astigmatic retinal defocus, or eye dominance, on simple eye-hand reaction time. However, gender differences revealed a consistent and significant effect of retinal defocus (p<0.001), with males being faster by approximately 30 msec across the range of retinal defocus conditions.

Conclusions: Simple eye-hand reaction time was robust to a wide range of amounts and types of retinal defocus, thus suggesting central neural insensitivity to blur for this simple performance task and target. The gender difference may be related to visuomotor experience.

Keywords: blur, driving, eye dominance, eye-hand reaction time, gender, refraction, retinal defocus

Introduction

The ability to interact optimally in one's environment requires the detection of, and response to, an object of interest and importance. One such response measure is reaction time,[1] which is presented here in a simplistic manner. This refers to the time interval between presentation of a sensory stimulus and the correlated behavioral response.[2] This response consists of two phases: sensory reception and central brain processing time of the target or the "pre-motor response," followed by the shorter "motor response" time. Their ratio is approximately 2:1 for simple reaction time.[3] The combination represents the overall reaction time.[3,4]

There are two main categories of reaction time: simple and choice. Simple reaction time is the faster of the two, when only one possible choice is available. In contrast, for choice reaction time, there are multiple possible response options, and hence it is slower. In earlier computer-based experiments, mean simple eye-hand reaction time in visually-normal subjects was approximately 265 msec.[5] Choice reaction time has been shown to increase logarithmically with the number of possible choices according to Hick's Law.[2,6] In one set of experiments, values ranged from 420 msec for a single choice to 630 msec with six choices, with approximately a 40 msec increase per additional choice.[7]

Reaction time is dependent upon a number of conditions related to the stimulus and its surrounding environment, as well as the internal and external state of the individual. For example, reaction time increases with retinal eccentricity, fatigue, and distraction.[3,8-11] In contrast, it decreases with stress.[8,12] There is also a gender effect; reaction time is faster in males by 30-40 msec.[8,13] Reaction time also increases with age, and it has been shown to do so at a greater rate in women than in men.[14]

Optically-based retinal defocus has also been demonstrated to have an adverse effect on many activities of daily living (ADL). Reading performance was reduced with 2.00D or more of retinal defocus. For example, a 23% decrease in reading rate was found with 3.00D of retinal defocus.[15] Blur also adversely affects object recognition by increasing recognition time.[16] Lastly, small amounts of spherical and astigmatic retinal defocus have been demonstrated to have a minimal effect on golf putting performance and accuracy.[17] In contrast, a large amount of defocus (i.e., +10.00D) has the opposite impact.[17] Thus, visuomotor performance is robust to relatively small amounts, but not to large amounts, of retinal defocus, in most cases. A large amount of retinal defocus degrades the spatial frequency components of the target,

especially in the high spatial frequency ones, thus making visibility more difficult in many cases.

Reaction time is of importance for many ADL. One such critical activity is driving. When driving, an individual is exposed to a variety of complex and dynamic stimuli (e.g., a darting child, merging cars, changing traffic lights, etc.) and changing environmental conditions (e.g., dim illumination at dusk or auditory distractions such as a radio or cell phone ring). For simple visual reaction time, quality of the retinal image of the relevant visual stimulus is a major factor in response time (e.g., a blurry green-red traffic light signal). Target luminance, spatial frequency content, retinal location, and contrast all have effects on the quality of the visual stimuli and have been shown to influence simple reaction time.[8,9,18] Other factors may also influence it. For example, Holahan[11] found increased reaction time due to distractions, and Phillip et al.[10] reported increased reaction time due to sleep deprivation. All of these factors may be especially relevant when driving long distances. Another instance related to driving in which target quality may become degraded is through optical defocus effects, as described earlier. This can occur in one of two main ways: not wearing one's refractive correction or wearing an improper correction. Such retinal defocus may make object detection and response time prolonged and/or more variable, either of which can result in a more dangerous driving condition.[19]

Another parameter of interest is eye dominance. Minucci and Connors[18] found that the dominant eye had a small but significantly faster reaction time than the non-dominant eye as assessed by sighting eye dominance: 243 msec and 252 msec in the dominant and non-dominant eyes, respectively. There is speculation in the literature that eye dominance may be a factor in driving,[20,21] especially in the United States and other countries incorporating driving on the right-hand side of the road. Since most people are right-eye dominant, when using the side view mirror on the driver's side to assess oncoming traffic from behind, with quick saccadic-based "glances" into the mirror, the facial anatomy (e.g., nose) may block the right eye, and thus the non-dominant left eye alone may be employed intermittently. This has been speculated to produce a lateral bias within one's driving lane.[20,21] Eye dominance can also be affected by a number of other factors, including a moderate difference in visual acuity between the two eyes.[22]

Thus, as a *first* probe into this important area, simple eye-hand visual reaction time was assessed under both binocular and monocular viewing conditions for a range of amounts and types of retinal defocus in a static test condition simulating the response to a red/green traffic stop/go signal in young, visually-normal adults.

Methods
Subjects

Sixteen optometry students between the ages of 22 and 27 years, with a mean age of 23.6 (± 0.5) years, participated in the study. There were 11 females and 5 males. Each had
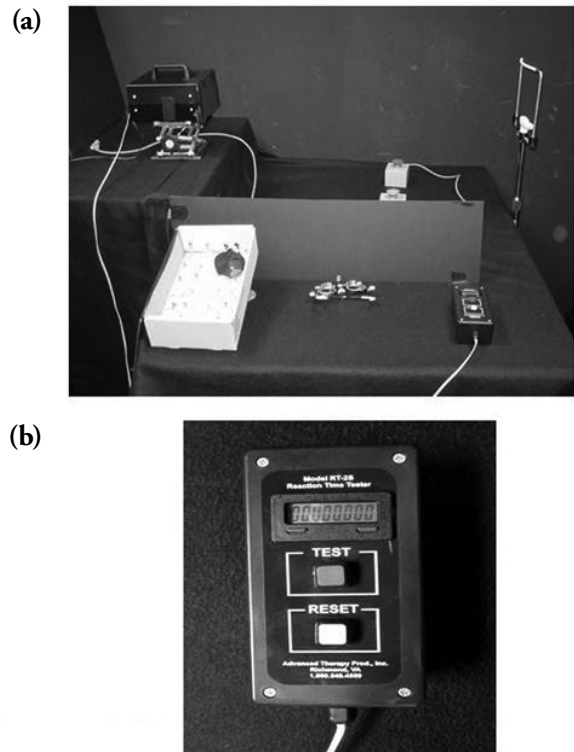

(a)

(b)

Figure 1. (a) Applied Therapy Systems RT-2S Simple Reaction Time Tester apparatus. Red and green test lights (upper left), red and green hand controls (upper right), test control box (lower right), and chin rest. (b) Close-up of test control box with test button, reset button, and digital reaction time display (in seconds).

undergone a comprehensive vision examination within the previous year including refractive, binocular, and ocular health status. Spherical refractive correction ranged from +0.25 to -5.75 D, with a mean of -2.23 D. The astigmatic error ranged from -0.25 to -1.25 D, with a mean of -0.83 D. All were fully corrected with their distance refractive correction through use of either an ophthalmic trial frame with appropriate trial lenses or contact lenses. Each had near and distance corrected visual acuities of 20/20 or better. All were visually normal binocularly with stereoacuity of 40 sec arc or better. There was no history of neurological, ocular, or systemic disease, or any form of acquired brain injury including mild concussion. None were taking any drugs or medications that might adversely affect either vision or general attention. They all reported feeling well rested and did not have any caffeine for at least 4 hours prior to testing. Prior to participation in the experiment, all subjects provided written informed consent. The study was approved by the SUNY College of Optometry IRB committee.

Eight of these same subjects also participated in a second experiment involving eye dominance. Four subjects were male, and four were female, with ages ranging from 22 to 27 years with a mean age of 24 (± 0.7) years. Sighting eye dominance testing was used (hole between hands technique).[22] Four subjects demonstrated left eye dominance, and four exhibited right eye dominance. Spherical refractive range was +0.50 to -5.75D, with a mean of -2.83 D; astigmatic errors ranged from -0.50 to -1.25 D, with a mean of -0.75 D.

Apparatus

The commercially-available RT-2S Simple Reaction Time Tester[a] was used for the study. The device consisted of red and green test lights, red and green controls used by the subject to respond to the stimuli, and a test control box run by the experimenters (Figure 1). The red and green test lights were placed at the subject's eye level at a distance of 100 cm. The test light apertures were 7.75 cm apart and 0.5 cm in diameter. This diameter is equivalent to 0.3 degrees of visual angle. It is the same as subtended by an 8.375-inch diameter traffic stoplight that is 120 feet ahead and 18 feet above the ground, which represents the standard light, distance, diameter, and height for traffic signals in the United States for this stopping distance.[23] The red light was situated on the right, and the green light was on the left. The red light had a luminance of 4 cd/m^2, and the green light had a luminance of 2 cd/m^2. The two hand controls were also red and green, and they were placed under the right and left hands of the subject, respectively. All subjects were right-handed. Subjects were positioned so that they could easily depress the buttons. The test control box consisted of a test button which initiated the reaction time testing, a reset button, and a stop clock that displayed digitally the reaction time in seconds measured to the one-thousandth of a second (i.e., msec). Testing was performed in a room free of external distractions. Low room illumination (5 lux) was used to reduce any glare and distraction. The experimenter was positioned behind a small divider to eliminate any peripheral visual cues that could possibly be provided to the subject when the test button was depressed to initiate stimulus activation, as well as to prevent the subject from seeing the reaction time meter values.

Procedure
Spherical and Astigmatic Retinal Defocus

To begin the experiment, subjects were instructed as to the overall test procedure. They were instructed to hold the green control button down to illuminate the green test light with their left hand, and to fixate the position where the red light would appear. The idea was to simulate the behavior an individual might exhibit while looking at a traffic light in order to ascertain when it changed to "red," which would then require a rapid braking action. The subject was informed that they would receive a warning signal, and furthermore that the experimenter would change the stimuli randomly within a time period of five seconds after this warning signal. They were instructed to depress the red button with their right hand as quickly as possible after the red light was illuminated. The subject was urged to minimize blinking during a trial in order to avoid missing the rapid stimulus change.

The subject was provided with earplugs to eliminate any possible distracting noises or sound cues from the test device. Auditory reaction times have been previously found to range between 140-160 msec as compared to simple visual reaction times, which might have a range as low as 180-200 msec.[24]

Thus, a sound cue might otherwise act as an experimental contaminant.

The subject was provided with a standard clinical ophthalmic trial frame with +1.00D trial lenses in both cells of the spectacle plane. These lenses made the subject optically conjugate with the test lights positioned one meter away. The subject also wore his or her habitual distance refractive correction in the ophthalmic trial frame, or contact lenses, with binocular viewing.

The subject was seated comfortably in a chair with his or her head placed in a chin and head rest assembly. An initial practice session was performed that included 30 trials. Based on the results of the practice trial, the mean and standard deviation of the reaction time were calculated from the last 25 responses. This was the subject's baseline. A range of acceptable values during the actual testing was determined to be ± two standard deviations from this mean value.

Retinal defocus greater than the subject's depth of focus will result in predictable gradations of perceived retinal blur.[25] Sixteen different defocus lenses were introduced in a counterbalanced manner across all subjects to minimize learning and order effects. The blur induced by the lenses included spherical: plano or zero diopters (D), +0.50D, +1.00D, +1.50D, +2.00D, +3.00D, +4.00D, and +10.00D, corresponding approximately to producing visual acuity levels of 20/20, 20/25, 20/60, 20/100, 20/180, 20/300, 20/500, and 20/2000,[26] respectively, and astigmatic: +0.50D x 90 and 180, +1.00D x 90 and 180, +1.50D x 90 and 180, and +2.00D x 90 and 180, corresponding to producing visual acuity levels of 20/20, 20/30, 20/40, and 20/60, respectively.[27] This large range of dioptric values was used to assess the effect of extremes in dioptric blur on target reaction time. For each magnitude of retinal defocus, trials were continued until there were 10 that fell within the accepted ± two standard deviation range that was previously determined. Less than 10% of the trials fell outside this range. Rest periods were introduced as necessary; at least one five-minute rest period was provided during each test session. Repeatability was assessed on two of the subjects. It was performed under the same conditions and time on a second day separated by at least two days.

Eight subjects from the initial group also participated in an eye dominance experiment. The instruction set was the same as for the earlier and more extensive retinal defocus testing. However, fewer defocus conditions were imposed. Eye dominance was established by using the sighting eye dominance procedure (hole between hands).[22] Following the practice session, testing commenced by introducing four different defocusing lenses in the ophthalmic trial frame: + 0.00D, +4.00D, +10.00D, and +2.00D x 90, monocularly and separately in front of each eye in a counterbalanced manner. The fellow eye was fully occluded with a black eye patch. These lenses were selected to represent a non-exhaustive but reasonable and large range of retinal defocus conditions.
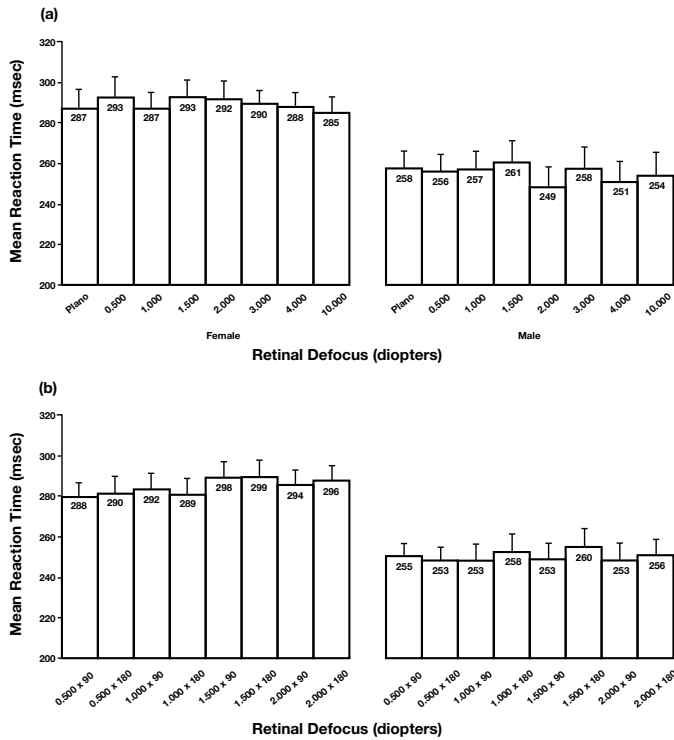
(a)

(b)

Figure 2: (a) and (b)

Figure 2. (a) Subgroup eye-hand reaction time as a function of spherical retinal defocus and gender (N_{female}=11, N_{male}=5). Plotted is mean reaction time +1 S.D. Number within each bar represents the mean reaction time of the subgroup for each defocus condition. (b) Subgroup eye-hand reaction time as a function of astigmatic defocus and gender (N_{female}=11, N_{male}=5). Plotted is mean reaction time +1 S.D. Number within each bar represents the mean reaction time for the subgroup for each defocus condition.

Statistical analysis was performed using GraphPad Prism 5. The data were stored in an Excel spreadsheet.

Results
Spherical and Astigmatic Retinal Defocus Group Findings

The group mean results for eye-hand reaction time as a function of spherical retinal defocus ranged from 275 to 283 msec, with it being lowest in magnitude with the 10.00D lens and highest in magnitude for the 1.50D lens. A one-way, repeated-measures ANOVA was performed for the factor of spherical retinal defocus, which was not significant [$F=0.774$ (7, 15), p=0.61].

The group mean results for reaction time as a function of astigmatic retinal defocus ranged from 278 to 283 msec, with it being lowest in magnitude with the 0.50 D x 90 lens and highest in magnitude with the 1.50 D x 180 lens. A one-way, repeated-measures ANOVA was performed for the factor of astigmatic retinal defocus, which was not significant [$F=1.212$ (7, 15), p=0.303].

Spherical and Astigmatic Retinal Defocus Sub-Group Findings

The group mean results for reaction time as a function of spherical retinal defocus and gender are presented in Figure
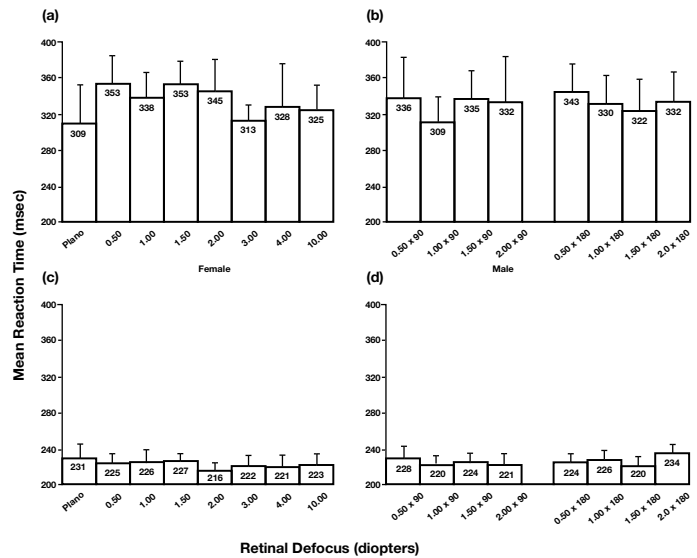

Figure 3: (a), (b), (c), and (d)

Figure 3. (a) Mean eye-hand reaction time as a function of spherical retinal defocus for the slowest subject (subject 15). (b) Mean eye-hand reaction time as a function of astigmatic retinal defocus for the slowest subject (subject 15). (c) Mean eye-hand reaction time as a function of spherical retinal defocus for the fastest subject (subject 16). (d) Mean eye-hand reaction time as a function of astigmatic retinal defocus for the fastest subject (subject 16). Plotted is mean reaction time +1 S.D. as a function of retinal defocus.

2(a). A two-way, mixed-model ANOVA was performed, in which spherical retinal defocus was the within-subject variable and gender was the between-subject variable. It was significant for gender [$F=409.6$ (1, 7), p=0.0001], but not for spherical defocus [$F=1.242$ (1, 7), p=0.391]. The mean reaction time across all spherical conditions for males was 255 msec, and it was 289 msec for females, a difference of 34 msec. For the extreme plano and +10.00D retinal defocus conditions, only three (out of 11) females were faster than the slowest male (276 msec).

The group mean results for reaction time as a function of astigmatic retinal defocus and gender are presented in Figure 2(b). A two-way, mixed-model ANOVA was performed, in which astigmatic retinal defocus was the within-subject variable, and gender was the between-subject variable. It was significant for gender [$F=586.1$(1, 7), p=0.0001], but not for astigmatic defocus [$F=1.482$ (1, 7), p=0.308]. The mean reaction time for all astigmatic conditions for males was 255 msec, and it was 293 msec for females, a difference of 38 msec.

Spherical and Astigmatic Retinal Defocus Individual Findings

Figure 3 presents the reaction time results for the slowest (a and b) and the fastest (c and d) subjects for spherical (a and c) and astigmatic (b and d) retinal defocus. For spherical defocus, the mean eye-hand reaction time of the fastest subject was 223 msec [range 216 (+2.00D) to 231 (plano) msec]. For the slowest subject, the mean was 333 msec [range 309 (plano) to 353 (+0.50D) msec]. For astigmatic defocus, the
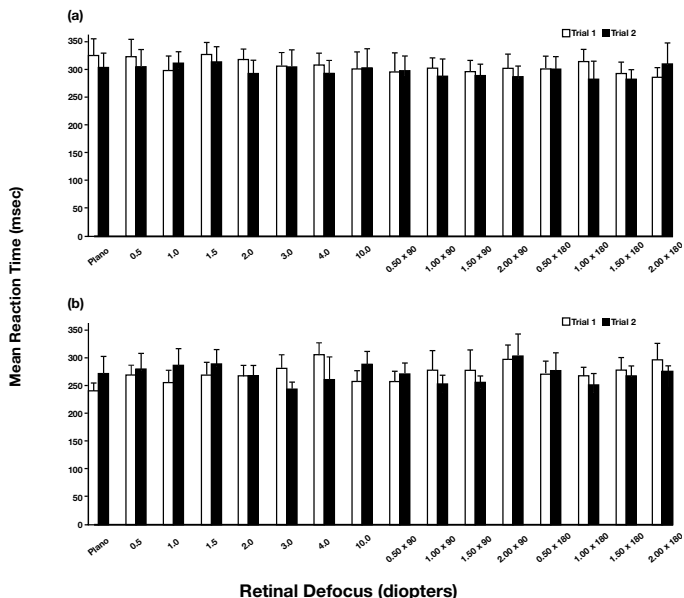
Figure 4: (a) and (b)

Figure 4. (a) Repeatability data for subject 1. Plotted is mean +1 S.D. eye-hand reaction time as a function of retinal defocus for the two trials. (b) Repeatability data for subject 11. Plotted is mean +1 S.D. eye-hand reaction time as a function of retinal defocus for the two trials.

mean eye-hand reaction time of the fastest subject was 225 [range 220 (+1.50D x 180) to 234.3 (+2.00D x 180) msec]. For the slowest subject, the mean was 328 msec [range 309 (+1.00D x 90) to 343 (+0.50D x 180) msec].

Other Findings

Linear regression and correlation analysis for all lens conditions were performed for mean reaction time verses refractive correction. None of the correlations were significant (p>0.05). R values ranged from +0.12 to +0.54, and p values ranged from 0.12 to 0.65.

Repeatability Findings

Subjects 1 and 11 participated in the experiment twice to assess repeatability. The results are presented in Figure 4 (a) and (b). The largest mean inter-trial difference was 33 msec for subject 1 and 44 msec for subject 11.

Eye Dominance Group Findings

The group mean results for eye-hand reaction time as a function of retinal defocus for the dominant and non-dominant eye ranged from 274 to 283 msec, with it being lowest for the plano or zero retinal defocus condition for the non-dominant eye and highest for the 2.00D x 90 retinal defocus for the dominant eye. A two-way, mixed-model ANOVA was performed, in which retinal defocus was the within-subject variable, and eye dominance was the between-subject variable. It was not significant for either defocus [F=0.124 (3), p=0.945] or eye dominance [F=0.472 (1), p=0.495]. The mean reaction time for all lens conditions under the monocular viewing conditions for males was 266

msec, and for females it was 295 msec, a difference of 29 msec. In males, the group mean reaction times for the dominant eye and the non-dominant eye were 266 msec and 265 msec, respectively. In females, the group mean reaction times for the dominant and non-dominant eye were 298 msec and 292 msec, respectively, with the non-dominant eye being faster.

Discussion

The present study demonstrated that different amounts of spherical and astigmatic retinal defocus, and consequent blur, had little adverse effect on simple eye-hand reaction time for this basic dichotomous test and the simple luminous targets used. Reaction time is composed of a slightly modifiable pre-motor reaction time and an apparently relatively fixed motor reaction time.[3,4] The present findings suggest limited influence for the visual system on the pre-motor processing time for reaction time under the retinal defocus test conditions used. Other factors including optical magnification effects and increased aberrations caused by the higher-powered, biconvex defocusing lenses could allow easier identification of the changed light stimulus in the presence of considerable defocus blur, therefore not resulting in an increase in simple reaction time. However, for more finely detailed and complex target arrays having high spatial frequency components such as present in a traffic sign, the results would likely be different. For example, if the simple eye-hand reaction time task comprised fine resolution-type targets, such as 20/20 letters on the Snellen chart or 20/50 sized reading material, a marked and progressive decrement in performance would be expected, as the retinal image contrast approached the subject's threshold for perception and edge sharpness decreased.[9,28]

Another possible mechanism to explain the lack of effect of blur on reaction time is blur adaptation.[25,29,30] Subjects may have adapted neuroperceptually to the low levels of persistent and chronic blur during testing, and thus may have experienced a relatively rapid recovery and reduction in perceived blur, with concurrent improvement in visual acuity/visual resolution. This effect is particularly evident in myopes,[31] which represented 14 of the 16 subjects in the present experiment. Furthermore, Webster et al.[32] noted that blur adaptation can occur after as little as two minutes of continuous blur exposure. In the present experiment, subjects had each set of lenses in place for at least seven minutes, for a total time of approximately 2.5 hours, during which they were nearly continuously exposed to varying degrees and types of blur. While counterbalancing prevented an order effect, it would not have prevented overall blur adaptation from taking place. However, this effect would likely be small, and therefore have minimal impact on the findings.[33]

Gender differences

Many previous studies found a gender-related reaction time difference: males were faster than females. The present results revealed a 34, 38, and 30 msec difference between

males and females for the spherical, astigmatic, and eye dominance conditions, respectively, with males consistently being faster. This difference in reaction time has been attributed by some to the traditional male dominance in sports and related activities.[34] This explanation may not be correct, however, as young women are as active in sports as men in our contemporary world. Therefore, the difference may be related to a genetic component causing a bias in the pre-motor component of reaction time. Interestingly, Der and Deary[14] proposed that there was a gender-based difference in speed verses accuracy, with men being faster, but with women being more accurate, thus suggesting a gender-based adaptive strategy. However, the present results revealed that women also exhibited greater variability than men, with standard deviations of approximately 27 msec verses 17 msec, respectively, which is not consistent with Der and Deary's findings.[14] However, this could be attributed to differences in test targets, type of reaction time tested, etc., between the present experiment and that of Der and Deary,[14] or other unknown factors. Further testing is warranted in this interesting and important area.

Eye dominance

In the present study, eye dominance did not have a significant effect on reaction time. Although not significant, the non-dominant eye typically had the numerically faster reaction time. This could be attributed to additional attentional aspects and/or oculomotor control aspects required to fixate and focus with the non-dominant eye. For example, in some subjects, Kenyon et al.[35] found that the objectively-recorded accommodative-vergence motor responses were less accurate, and subjectively harder to execute with greater attentional demand, when the non-dominant versus the dominant eye was tested in some experienced subjects under monocular viewing conditions.

Implications of the Present Study for Driving

When driving, a fast and efficient reaction time is important to ensure the safety of the driver, passengers, others vehicles, and surrounding pedestrians. The present study did not demonstrate any effect of varying amounts and types of retinal defocus on simple eye-hand reaction time to simple luminous targets having the same angular subtense as a standard traffic light from 120 feet away. This finding suggests that an accurate refractive correction *may not* be required for responding time-optimally to simple traffic light changes. However, nearly all other driving tasks *would* require proper correction and good visual acuity/visual resolution, such as reading traffic and exit signs. Furthermore, the present test conditions were static in nature, and under more dynamic testing/viewing conditions as occur during driving, presence of blur may have a more adverse effect. Reaction time for these dynamic detection and discrimination tasks would likely be increased by retinal defocus and the resultant blur,

and therefore an accurate refractive correction should *always* be worn when operating any type of motor vehicle under all circumstances in order to cover all possible conditions and contingencies. Eye dominance may also have a subtle effect on control and directional centering of one's driving,[20,21] and this warrants further detailed testing.

The present study has additional implications with respect to driving, especially from the perspective of the occupational therapist.[36,37] One of their primary responsibilities is driving testing/re-education, for example in the very elderly. The RT-2S device has been used successfully in this "at risk" population.[36] The present investigation demonstrated the robustness of optical blur on simple eye-hand reaction time with a diffuse, luminous source having a paucity of details in young, healthy individuals. However, this may not be the case in the elderly with their higher prevalence of retinal and vitreal problems, which may physically obstruct/obscure the relevant stimulus to some extent, perhaps intermittently with variation and difficulty in saccade/fixation execution. Furthermore, this may not be the case for more complex and dynamic situations rich in detail and relevant information, as mentioned earlier, and as may be found with a driving simulator or in an actual driving environment, in this and other "at risk" populations, such as brain injury/disease.[38] In the aforementioned populations and conditions, optical blur may in fact have an adverse effect on driving ability, in which concurrent cognitive and/or attentional deficits may be present that contribute to the overall potential visual perturbations. Such testing should be performed in future studies. Lastly, the RT-2S device should be used as a first line of testing in these at risk populations, and depending on the results, driving testing could be extended to the driving simulator or even natural driving environment.

Study limitations

There were some possible study limitations. Only one test stimulus was used, which may not generalize to the wide range of targets/stimuli found in driving, such as resolution targets (e.g., an exit number) that might be more susceptible to defocus effects. Such a non-detailed and diffuse stimulus, as used in the present study, might be robust to defocus over a large range of magnitudes and types, as it may be asymptotic response-wise at the lower limit of the reaction time versus detectability function.[39] However, it did represent an important and realistic test target related to driving.

Further Directions

Testing should also be performed under dynamic conditions, as this is relevant in many ADL, such as driving. Other testing of interest would be assessing the effect of retinal defocus on simple reaction time to discriminate targets, as this is important in many situations such as driving. For example, Bruner & Potter[16] found that object recognition time for simple reaction time increased with blur; hence, a proposed

increase in eye-hand reaction time would also be expected for target discrimination tasks.

The present experiment should also be performed on individuals with traumatic brain injury, especially those seeking driving reinstatement. Previous studies have shown an increase in simple eye-hand reaction time and related variability in individuals with traumatic brain injury.[40-42] Reaction time was especially increased with more severe TBI immediately after the injury took place.[40-42] For example, Stuss et al.[40] found an increase in reaction time ranging between 43-90 msec, with variability increased 2-3 times, in TBI subjects as compared to normals. Such increases in mean reaction time could cause safety problems with driving.

Conclusion

Retinal defocus did not have a significant effect on eye-hand reaction time in visually-normal individuals. This finding suggests that blur may be tolerated, and in fact inconsequential, for selected simple, suprathreshold detection tasks. However, for more fine-detailed tasks, such as reading signage under dynamic viewing conditions (e.g., driving), it would likely have a major adverse effect. These findings are also consistent with previous results regarding gender differences for reaction time, with the underlying mechanism remaining elusive and speculative in nature.

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