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Effect of age and pop out distracter on attended field of view

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KEYWORDS
Attention;
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Abstract
Purpose: To investigate the functional field of view (FFOV) of younger and older individuals using the attended field of view (AFOV), a method which allows for eye and head movement. The impact of a pop out distracter and a dual task on the FFOV measure was also investigated.
Methods: Nine young adult (25 ± 6 years) and 9 older participants (72 ± 4 years) took part in the experiment. The AFOV test involved the binocular detection and localization of a white target (Landolt-C) in a field of 24 white rings (distracters). The further AFOV tests were modified to include the presence of a pop out distracter, a dual task condition, and a combination of the two.
Results: Older observers had lower viewing efficiency (log [1/presentation time]) in all conditions (pooled mean across conditions: older: 0.05 ± 0.02; younger: 0.48 ± 0.04) than the younger group. The addition of dual or a pop out distracter did not affect the older group (mean difference ∼104 ± 150 ms and ∼124 ± 122 ms respectively) but the additional pop out distracter reduced the efficiency of the younger group for targets near fixation (mean difference ∼68 ± 35 ms).
Conclusion: Better viewing efficiency was observed in younger individuals compared to older individuals. Difficulty in disregarding irrelevant stimuli and thereby resorting to inefficient search strategy is proposed as the reason for the differences. The finding that both older and younger individuals are not affected significantly by the presence of the irrelevant pop out distracter has implications in situations such as driving or hazard avoidance. In such scenarios, search performance is likely not impaired beyond what is found with distracters (visual clutter) in the environment.

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PALABRAS CLAVE
Atención;
Distractores;
Edad;
Campo visual funcional;
Estímulos sobresalientes

Efecto de la edad y distracciones repentinas sobre el campo visual esperado

Resumen

Objetivo: Investigar el campo visual funcional en pacientes jóvenes y mayores, utilizando el campo visual esperado: un método que permite el movimiento de los ojos y de la cabeza. También se investigó el impacto de una distracción repentina y de una doble tarea sobre la medición del campo visual funcional.

Métodos: Se incluyó en el experimento a nueve jóvenes (25 ± 6 años) y 9 mayores (72 ± 4 años). La prueba del campo visual esperado incluyó la detección y localización binocular de un objetivo blanco (C de Landolt) en un campo de veinticuatro anillos blancos (distracciones). Se modificaron posteriormente las pruebas del campo visual esperado para incluir la presencia de una distracción repentina,, una situación de doble tarea, y una combinación de las dos pruebas.

Resultados: Los observadores de más edad reflejaron una menor eficiencia visual (log [1/tiempo de presentación]) en todas las situaciones, (media conjunta de todas las situaciones: Mayores: 0,05 ± 0,02; Jóvenes: 0,48 ± 0,04) que el grupo de menor edad. La adición de una tarea dual o una distracción repentina no afectó al grupo de mayor edad (diferencia media ∼104 mseg ± 150 mseg y ∼124 mseg ± 122 mseg respectivamente), aunque el distractor sobresaliente adicional redujo la eficacia del grupo más joven para los objetivos cercanos a la fijación (diferencia media ∼68 mseg ± 35 mseg).

Conclusión: Se observó una mejor eficiencia visual en los pacientes más jóvenes, en comparación a los mayores. La dificultad de ignorar los estímulos irrelevantes, y por tanto, de recurrir a una estrategia de búsqueda ineficaz, se propone como motivo de las diferencias. El hallazgo de que tanto los pacientes jóvenes como los mayores no se ven afectados en demasía por la presencia de una distracción repentina irrelevante tiene implicaciones para situaciones tales como la conducción o evitar peligros. En tales escenarios, no es probable que dicho desempeño de búsqueda se vea afectado más allá de los hallazgos obtenidos con las distracciones (desorden visual) en el entorno.

Attention influences performance in driving. Driver inattention (due to fatigue, drowsiness, etc.) and distraction can result in automobile crashes.[1] Distraction can be due to a variety of causes such as an activity outside the vehicle, a person in the car, or devices such as cell phones, radios or other gadgets. It results in delayed recognition of necessary information, and shifts attention from the primary task of driving.[1,2] The effect of distraction can also be observed in other situations requiring hazard avoidance such as walking.[3] Older individuals have been shown to be more detrimentally influenced by distraction while walking than younger adults[4,5] It has been suggested that distraction effects are due to a filtering problem where the individual finds it difficult to inhibit the processing of less important stimuli, resulting in a greater processing load.[6,7] The inhibitory mechanism which suppresses the processing of distracting information is affected by increasing age, resulting in overall longer processing times with age.[6,7] Kramer et al.,[8] however, found that the onset of a task irrelevant distracter in the search display affected the visual search times of both younger and older individuals almost equally. Understanding how performance varies in attention demanding situations such as in presence of multiple distracters/clutter and also during abrupt onset of targets is important because of its relevance to dynamic tasks such as walking and driving.

One of the methods to study performance in an attention demanding situation is the functional field of view. The functional field of view (FFOV) is defined by Mackworth[9] as ''the area around the fixation point from which information is briefly stored and read aloud during a visual task'' (p. 67). Ball and associates[10,11] describe the FFOV as the total visual field area from which information can be extracted without eye and head movements in situations of dual tasking and/or visual clutter and refer to it as the ''Useful field Of View'' (UFOV®). Many research groups have used the UFOV® or similar tests, wherein a target has to be localized, with or without distracters.[11–13] The presentation time is brief so that responses must be made in the absence of eye movements. Coeckelbergh and associates[14,15] used a paradigm to measure FFOV that allows the use of eye and head movements. They call this the Attended Field Of View (AFOV). The rationale for creating the AFOV test was that, in real life, people seldom perform visual search without moving their head and/or eyes.

The UFOV®[16,17] and similar FFOV tasks[18] can include a dual task condition with or without the distracters mentioned above. In the dual task condition, participants are required to count or make judgments about central targets, while simultaneously detecting the location of a target in their peripheral visual field. In our study, an AFOV test was used to measure the functional field of view and the effect of eccentricity. We also introduced an additional irrelevant distracter in the AFOV test. The additional distracter was dissimilar in one feature, namely color, from all the other distracters. Our hypothesis was that the irrelevant pop out distracter would attract more attention than the target, making target identification more difficult. The effect of age was investigated by comparing the responses of older adults to those of young adults. Our specific questions were: (1) Can we confirm a reduction in viewing efficiency in older adults compared to young adults? (2) Do older adults have reduced viewing efficiency in the presence of an irrelevant pop out distracter? (3) Do older adults have reduced viewing efficiency in dual task conditions both with and without the presence of a pop out distracter? The novel features of this study were including an irrelevant pop out distracter in the AFOV and also including a greater central load to study divided attention. The importance of investigating these characteristics of the AFOV is to understand if the reduced functional field of view in older individuals is further reduced in presence of an irrelevant pop out distracter. If this hypothesis holds true, then this would have implications in situations of hazard avoidance such as driving, walking and other tasks.

Methods

Participants

Nine young adult participants with a mean age of 25 ± 6 years and 9 older participants with a mean age of 72 ± 4 years took part in the experiment. The younger participants included students and staff, recruited from the School of Optometry and Vision Science at the University of Waterloo. The older participants were recruited from the School of Optometry Clinic at the University of Waterloo and were screened for cognitive impairment using a standard Mini-mental state exam questionnaire.[19] Only participants with corrected visual acuity better than 6/9 and no known visual field defects were included. Participants were excluded if they had any ocular pathology, oculomotor, neurological or vestibular anomalies. During the testing, the older participants were either provided with their near correction in a trial frame or asked to wear their own single vision near spectacles to allow for good visual acuity at the testing distance.

Approval for the study was obtained from the Office of Research Ethics at the University of Waterloo. Informed consent, in compliance with the Declaration of Helsinki, was obtained from all the participants.

Apparatus

Custom software for the Attended Field of View test was made using the Experiment Builder (SR Research®, Toronto, Canada). A 19 in. LG monitor connected to a 2.4 GHz Intel Core PC was used to display the stimuli. The participants were seated 50 cm from the screen with their eyes aligned to the center of the screen. A standard keyboard and mouse were used to respond to the stimuli.

Procedure

The AFOV test was designed following Coeckelbergh et al.[15] and involved binocular detection and localization of a white target (Landolt C) that subtended 1.1° at 50 cm with a gap of 0.2°. The Landolt C had to be detected in an array of 24 white rings. The rings were positioned on a grid along eight radii (oriented at 0, 45, 90, 135, 180, 225, 270, and 315°) and at three eccentricities (4, 8, and 12° from the center of the screen). The target and the distracter rings appeared on a gray background giving 50% contrast. One white ring also appeared in the central location, although the target never appeared at this location. The target and the other elements appeared simultaneously in the display – Fig. 1. The target (Landolt C), oriented in one of the four possible directions (up, down, left, right), was displayed at 9 of the 24 possible locations (3 locations at each eccentricity) presented in random order, except that the location of the target was never at the same location as in the previous trial. The nine locations were positioned on the 45 and 135 meridia. Participants were not informed that only nine locations were tested. The time taken to perform the test would have been considerably longer if all the available 24 locations were tested, potentially making fatigue an issue. Upon debriefing after the experiments, the participants responded that they were not aware that only some locations were tested.

The experiment started with a central fixation cross being displayed for one second. Following this, the display containing the target at one of the nine locations and the other white circles (distracters) appeared (see Fig. 1). The initial presentation time was set at 350 ms. Following this, a mask (a combination of black, white and gray squares) appeared for 800 ms. The purpose of the mask was to eliminate any afterimages of the target and distracters. After the mask, the response screen appeared and the participants had to move the mouse and click at the location where the target was observed. If the target was not observed, the participants were asked to guess. In the next screen, the orientation of the target was indicated by pressing the up, down, left or right arrow key on the keyboard. Following this, the fixation cross appeared at the central location and the procedure was repeated for the next trial. Those individuals who had difficulty with the mouse and keyboard were asked to point to the location and verbally report the orientation. The experimenter entered these responses using the mouse and keyboard for every trial. An independent staircase for the presentation time was run at each of the nine target locations. The presentation time was increased if localization of the target was incorrect and decreased if it was correct, in a weighted up-down manner (0.2 log unit up and 0.1 log unit down), such that the percentage of increase was higher than the decrease, resulting in a 67% correct threshold. Forty trials were presented at each location and in all cases more than 8 reversals were obtained. The average of the response reversals for each eccentricity, excluding the highest and lowest reversal values, was taken as the measure of time to locate the target. Although the orientation of the Landolt C was to be judged, this judgment did not affect staircase presentation time. This first experiment will be referred to as the ''standard AFOV'' (Fig. 1 – top left panel).

In the second experiment, the effect of a single pop out distracter on AFOV performance was investigated. The experimental task remained the same, but in this case, one of the white rings was replaced with a red ring (pop out distracter). The location of the red pop out distracter varied with every trial randomly, occupying one of 23 available

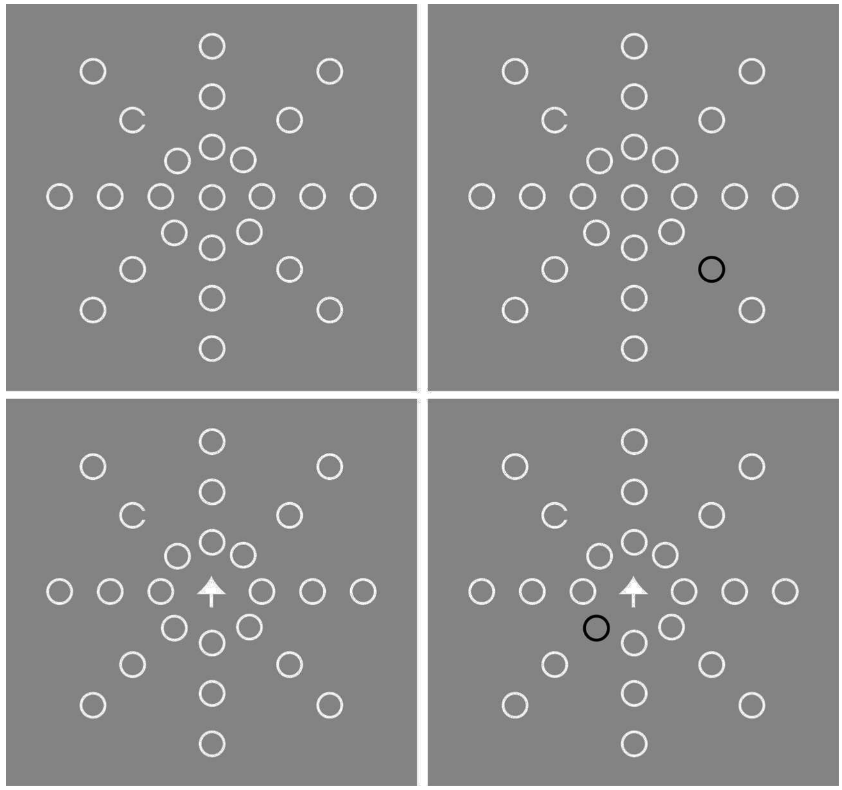

Figure 1 Representation of AFOV stimuli: standard AFOV (top left), standard AFOV with pop out distracter (top right), dual AFOV (bottom left), dual AFOV with pop out distracter (bottom right).

positions. The participants were instructed to ignore the red ring and still search for the target (Landolt C) (Fig. 1 – top right panel). The location of the target and the orientation of the ''C'' were identified as described in the first experiment. Experiment two will be referred to as ''standard AFOV with pop out distracter''.

In the third experiment the AFOV test was modified to create a dual task situation. The central target was replaced with an arrow oriented in one of four directions (up, down, left or right). The experiment started with the display of a central fixation cross lasting for one second. After this the stimulus containing the target (Landolt C) at one of the nine locations and the distracters (other white circles) appeared along with the central arrow oriented in one of the four directions (Fig. 1 – bottom left panel). The position and orientation of the Landolt C and the direction of the arrow were randomized independently. This display was followed by a mask lasting for 800 ms, as before. In this case, the participants were required to first report the direction of the central arrow (using the arrow keys on the keyboard) and then indicate the location of the target. A response regarding the orientation of the Landolt C was not required in this case. This was done to avoid confusion between the orientation of the central target and the direction of the Landolt C. As in the standard AFOV, 9 locations were tested (3 at each eccentricity). Participants were not informed of the fact that some locations were not tested. Forty trials were presented at each location and in all cases more than 8 reversals were obtained. In cases where the response for the direction of the central arrow was wrong, the trial was put back into the sequence of the staircase for that location. Details regarding the staircase run at each location remained the same as described in experiment one. Experiment three will be referred to as ''dual AFOV''.

The pop out distracter effect on the dual AFOV was investigated in experiment 4. One of the distracter locations was replaced with a pop out distracter (red ring) (Fig. 1 – bottom right panel). This experiment will be referred to as ''dual AFOV with pop out distracter''.

The pop distracter condition was considered to be too difficult for some participants to perform as the first experiment; therefore, the order of the experiments was not randomized or counterbalanced. As such, practice effects could play a role but the opportunity to learn remained identical for all participants.

The inverse of the average presentation time in seconds for each eccentricity was log transformed and reported in terms of ''viewing efficiency''.[14,15]

$$\text{Viewing efficiency} = \text{Logarithm}\left(\frac{1}{\text{Average presentation time in seconds}}\right)$$

The logarithmic transformation, as suggested by Coeckelbergh et al.,[15] made the distribution normal (Kolmogorov–Smirnov test, $d = 0.1$, $p > 0.05$) and allowed the use of parametric statistics to perform the analysis.

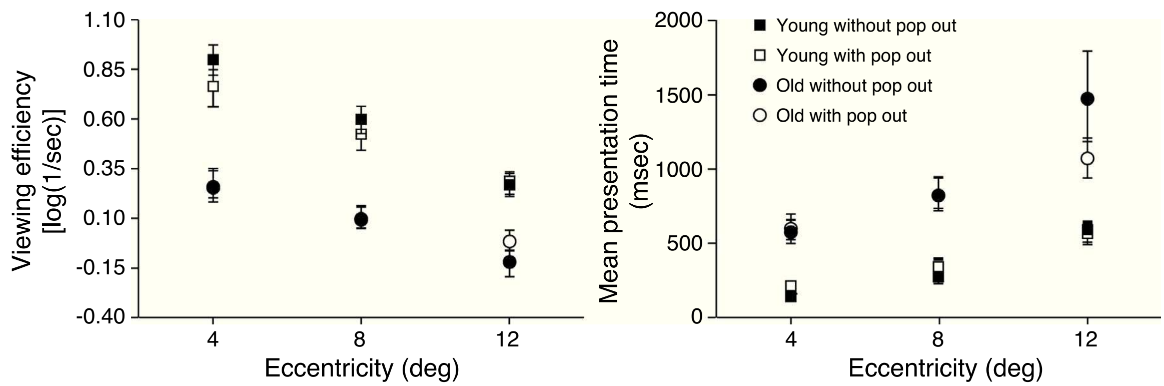

Figure 2 Left panel – Experiment 1 (standard AFOV without the pop out distracter) and experiment 2 (standard AFOV with the red pop out distracter). Viewing efficiency (logarithm of inverse of threshold presentation time in seconds) is plotted against eccentricity for the two age groups. The error bars represent standard error of the mean. Right panel: the data on the left panel are re-plotted on a linear scale. Average presentation time in milliseconds is plotted against eccentricity.

Statistical analysis

A repeated measures ANOVA was performed on the log transformed data ([2 tasks; pop out distracter vs. no pop out] × Eccentricity [4, 8 and 12°]) for the standard AFOV and AFOV with pop out distracter (experiments 1 and 2). Comparison between standard AFOV and dual task AFOV (experiments 1 and 3) was also done using a repeated measures ANOVA ([2 tasks; standard AFOV without pop out distracter vs. dual task AFOV] × Eccentricity [4, 8 and 12°]). Similarly the same type of analysis was used for conditions comparing the standard AFOV with pop out distracter and the dual task AFOV with pop out distracter (experiment 2 and 4). Age was considered the between-subject variable in all cases. A post hoc analysis with a Bonferroni correction was used to compare the differences between the means. The p values reported are Huynh–Feldt corrected in cases where the assumption of ANOVA with respect to sphericity was violated.

Results

Experiments 1 and 2 (standard AFOV with and without pop out distracter)

There was a main effect of age [$F(1,16) = 28.35$, $p < 0.001$] and a main effect of eccentricity [$F(2,32) = 68.55$, $p < 0.001$]. With increasing eccentricity, viewing efficiency decreased. This was the case for both age groups (Fig. 2 – left panel). There was no main effect of pop out distracter on the viewing efficiency [$F(1,16) = 0.52$, $p = 0.478$]. There was a significant interaction of pop out distracter × age [$F(1,16) = 0.067$, $p = 0.049$] and a significant interaction of pop out distracter × eccentricity [$F(2,32) = 8.04$, $p = 0.002$]. A significant interaction was also observed for eccentricity × age [$F(2,32) = 4.38$, $p = 0.021$]. Post hoc analysis on significant higher order interaction terms ($p < 0.05$) showed that there was a significant effect of pop out distracter at the 4° eccentricity for the younger group ($p = 0.014$) wherein reduced viewing efficiency was observed in the presence of the pop out distracter. There was no impact of the pop out distracter at other eccentricities for either group ($p > 0.1$). It can be seen that, at the 12° eccentricity, the viewing efficiency of the older group appears better with the pop out distracter than without, but the difference was not statistically significant. The data were also plotted on a linear scale, depicting presentation times, as is common in other studies of functional field of view (Fig. 2 – right panel, Table 1). On this scale the differences appear greater.

Experiments 3 and 4 (dual task AFOV with and without pop out distracter)

There were main effects of age F [$(1,16) = 27.32$, $p < 0.001$] and eccentricity [$F(2,32) = 68.55$, $p < 0.001$]. With increasing eccentricity, viewing efficiency decreased. This was the case for both groups (Fig. 3 – left panel). There was no main effect of pop out distracter on viewing efficiency [$F(1,16) = 0.11$, $p = 0.748$]. There was no interaction of pop out distracter × age [$F(2,32) = 0.43$, $p = 0.519$] or of pop

Table 1 Summary of the results in each condition in young and old.

	Young (ms ± SE)			Older (ms)		
	4° E	8° E	12° E	4° E	8° E	12° E
Standard AFOV	142 ± 25	278 ± 43	576 ± 67	580 ± 76	833 ± 113	1489 ± 305
Standard AFOV + red pop out	209 ± 42	336 ± 54	561 ± 66	612 ± 90	836 ± 102	1081 ± 129
Divided/dual AFOV	117 ± 18	230 ± 26	608 ± 77	700 ± 170	734 ± 102	1155 ± 142
Divided/dual AFOV + red pop out	118 ± 13	220 ± 28	541 ± 56	683 ± 167	752 ± 125	1171 ± 117

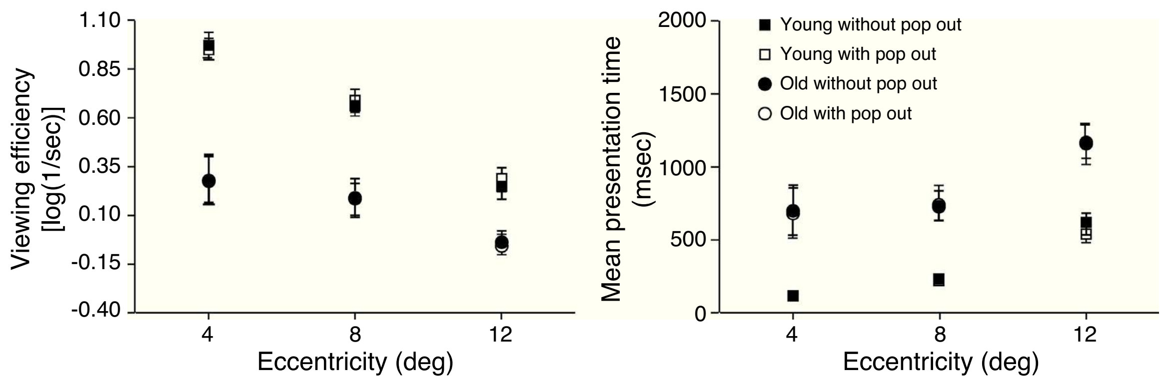

Figure 3 Left panel — experiment 3 (dual AFOV without the pop out distracter) and experiment 4 (dual AFOV with the red pop out distracter). Viewing efficiency (logarithm of inverse of threshold presentation time in seconds) is plotted against eccentricity for the two age groups. The error bars represent standard error of the mean. Right panel: the data on the left panel are re-plotted on a linear scale. Mean presentation time in milliseconds is plotted against eccentricity.

out distracter × eccentricity [$F(2,32) = 0.42$, $p = 0.664$]. Thus there was no impact of the pop out distracter at any eccentricity for either group ($p > 0.1$). Fig. 3 (right panel) and Table 1 represent the threshold data on a linear scale.

Comparison of standard and dual AFOV without pop out distracter (Expt 1 and Expt 3)

There was a main effect of age [$F(1,16) = 35.75$, $p < 0.001$] and a main effect of eccentricity [$F(2,32) = 70.10$, $p < 0.001$). There was no main effect of condition (standard vs. dual AFOV, $F(1,16) = 2$, $p = 0.176$). There was no interaction between age and condition (standard vs. dual AFOV, $F(1,16) = 0.07$, $p = 0.797$) and the trend was the same for both age groups (Fig. 4A and Table 2).

Comparison of standard AFOV and dual AFOV with pop out distracter (Expt 2 and Expt 4)

There was a main effect of age [$F(1,2) = 25.97$, $p < 0.001$]. There was also a main effect of eccentricity [$F(2,32) = 62.52$, $p < 0.001$] and condition (whether it was standard or dual AFOV [$F(1,16) = 5.25$, $p = 0.036$]). Better viewing efficiencies were observed in dual AFOV conditions. There was no interaction of this effect with age [$F(1,16) = 2.62$, $p = 0.125$] — Fig. 4B and Table 2.

The position of the pop out distracter might help locate the target (Landolt C), by drawing attention to it. In other words, there would be fewer errors when the pop out distracter was adjacent to the target and more when it was further away. In order to test this possibility, we investigated the location of the pop out distracter relative to the target when incorrect responses occurred in the staircase. For the targets at 4 and 12° eccentricity, 5 locations were considered as neighboring locations. For the targets at the 8° eccentricity, 8 locations were identified as neighbors. Targets were considered as neighbors when the distracters were present adjacent to the target on the same ring as well adjacent on the ring next to it. The percentage of incorrect responses when the pop out distracters were at neighboring locations was calculated and compared to the expected value. The expected percentage in this case was 5 out of 22 (22 refers to the total number of available locations for the pop out distracter to appear) which corresponds to 22.72%, and 8 out of 22 which corresponds to 36.36%. The data obtained

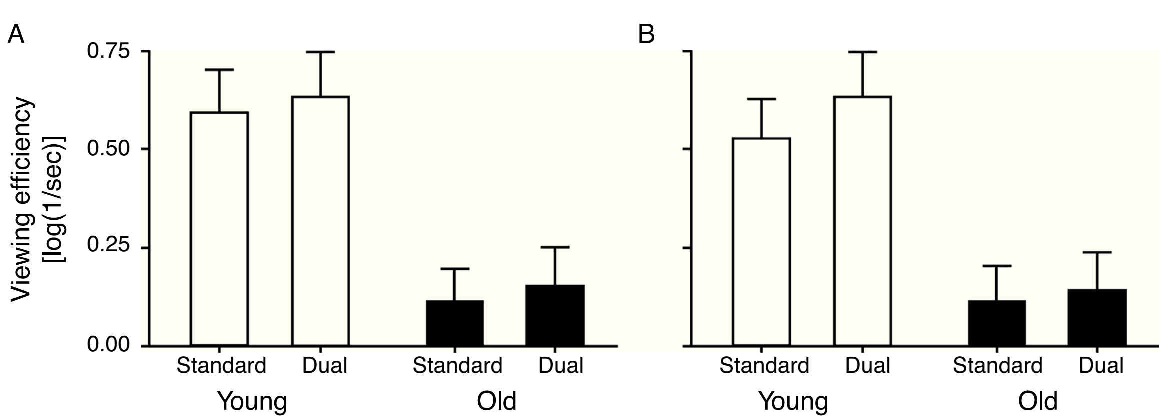

Figure 4 Comparison of data pooled for eccentricities for both standard AFOV and dual AFOV (A) without pop out distracter (B) with pop out distracter. Viewing efficiency (logarithm of inverse of average presentation time in seconds) is plotted against type of AFOV for two age groups. The error bars represent standard error of the mean.

Table 2 Summary table; data pooled for all three eccentricities.

	Young (ms ± SE)	Older (ms)
Standard AFOV	332 ± 45	967 ± 165
Standard AFOV + red pop out	369 ± 54	843 ± 107
Divided/dual AFOV	318 ± 40	863 ± 138
Divided/dual AFOV + red pop out	293 ± 32	869 ± 136

for the standard AFOV and dual AFOV with pop out distracter are shown in Fig. 5.

In all the cases, the number of errors was higher than expected when the pop out distracter was at a neighboring location. It was observed that about 30% of the time, the pop out distracter was at a location near the target, for the 4 and 12 eccentricities. An even higher percentage was obtained for the 8° eccentricity, which was close to 50%. This indicates that the proximity of the distracter did not improve performance. This analysis should be considered qualitative only as there are other variables including the number of times that the target might have appeared at a particular location, etc. that we have not taken into consideration.

Discussion

The results of the first experiment (standard AFOV) show that younger participants have better viewing efficiency than the older individuals at all three eccentricities. This could be due to different search strategies being used by the two age groups when identifying targets. Conventionally, parallel processing refers to visual search where all the information is processed in parallel (at the same time) and involves the preattentive stage.[20,21] Such processing usually occurs when the target has one or more feature that is unique from all the distracters The target pops out from the background and can be located in very short presentation times. In serial processing, each item or area in the display is scanned sequentially. Serial processing occurs when more features of the target are shared by the distracters and the search is referred to as conjunction search.[21,22] The similarity of the target and distracters plays a role in determining whether the search is parallel or serial. More recent models of visual search propose that a search could be characterized as ''efficient'' or ''inefficient''.[23,24] An efficient search is one where the initial stage is able to guide the attention appropriately so that very few locations need to be searched in the subsequent stage. Inefficient searches are those where the initial processing does not guide attention to a particular location, resulting in many more areas being searched before termination of the search. In a visual search task, some attributes of the stimulus such as color, motion, orientation, and size are ''undoubtful attributes''[24] that are certain to capture attention or guide the attention process to locate a target. Other attributes such as shape, closure, and Vernier offsets are considered ''probable attributes'', which may capture attention, although not always.[24] In the AFOV (standard), the target is different from the distracters in closure, and since this is a ''probable attribute'', the identification of the target can either be an outcome of efficient or inefficient visual searches. It is likely that, as the stimulus in our conditions was a probable attribute, the older participants performed inefficient searches resulting in reduced viewing efficiency compared to the younger participants.

In our experiment we also found that the viewing efficiency decreased with increasing eccentricity for both younger and older participants. However, the eccentricity effect is greater for the younger than the older individuals, which is probably because the older people perform less efficient searches at all eccentricities. This is similar to what other researchers have observed.[14,15] The reduced saliency differences between target and the distracter[17,25] could be responsible for impeding the search performance. Another reason for the poorer performance of older individuals could be the need to make eye movements to identify the target.

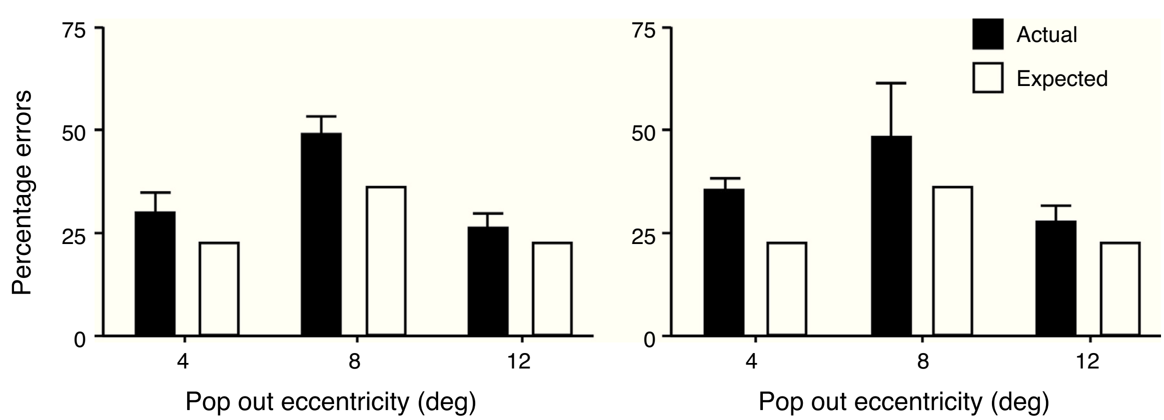

Figure 5 Left panel — Pop out distracter location effect on standard AFOV — Experiment 2. Right panel — pop out distracter location effect on dual AFOV with pop out distracter (Experiment 4). Actual number of errors is shown against the expected.

Scialfa et al.[25] report that older participants made two to three times more saccades than the younger group, in a study of eye movements and age. Another recent study[26] measured eye movements during a manual tracking task in which adjustments were made using a joystick to keep a cursor (which was presented eccentrically) in the middle of the display. This study also found that older people compensate for their reduced functional field of view by making more illicit saccades. Although we do not have data to support this claim, it is highly likely that the older individuals made more eye movements in a serial situation where each group of locations was scanned one after another.

In experiment 2 (standard AFOV with pop out distracter) we found that the presence of the pop out distracter (the red ring) resulted in reduced viewing efficiency for younger individuals for targets near the central location. One possibility is that younger participants started their search from the center and the presence of a color distracter target at a different location impeded their search performance. This would be likely as the color attribute has a stronger influence than the ''closure'' attribute in attracting or guiding attention.[24] We then have to ask why the pop out did not have an impact at the 8 and 12° eccentricities. The probable reason is that at these eccentricities the younger participants were already undertaking more inefficient ''serial'' searches, as the target saliency is not very high. We speculate that, in conditions where participants already scan more locations to identify the target, the pop out distracter itself will have little or no effect on the total time taken to identify the target. This result is rather surprising, as heterogeneous distracters are seen to produce higher error rates on UFOV.[25] However, in a UFOV, the condition is formulated for efficient searches and the outcome is binary, i.e. participants perform the task with lower or higher error rates. Similarly, if the older individuals are already making inefficient visual searches in the standard AFOV, then the presence of the pop out distracter will not result in increased presentation times. Colcombe et al.[27] and Kramer et al.[8] also found that the presence of an onset (target appearing abruptly) or colored distracter did not affect their older group more than the younger individuals. They attribute their finding to goal directed behavior and the ability to ignore the irrelevant distracter being intact or not changing with age. In studies of UFOV and AFOV, they find that the target identification at peripheral locations resulted in more wrong responses or reduced visual efficiency as we find in this study.

The results of experiments 3 and 4 assess viewing efficiency of the AFOV in dual task conditions with and without the pop out distracter. Similar to experiments 1 and 2, a significant impact of age was observed, but no effect of the distracter or the additional task. The inclusion of the central task ensures that participants start their search from the central location. Moreover, if the participants were inaccurate on the central task, the trial was put back into the sequence of the staircase.

Studies that have investigated visual search with divided attention tasks have shown that older people perform more poorly than their younger counterparts.[10,11] The differences between the age groups are thought to be due to greater divided attention costs for the elderly. However, not all studies that utilized UFOV® find greater divided attention costs for the elderly. The presence of distracters has been shown to have a greater impact on performance than the competing central task.[12] These results suggest that the mere presence of distracters makes it harder for older individuals to identify the target location.[12] Somberg and Salthouse[28] suggest that divided attention costs may be nullified if the baseline performances are equated between younger and older individuals. When they made this normalization, the older participants were seen to have no greater divided attention cost than the younger participants.

The viewing efficiency we observe in this study is much lower than that observed in the study by Coeckelbergh et al.[15], i.e. the times taken were longer. The use of the backward masking in our study might have resulted in the higher error rates, resulting in increased thresholds.[29] The effect of practice may have also influenced the outcome of the current experiments. As the distracters (white rings) and pop out distracter (red ring) are the same color in all trials, participants could learn to ignore the pop out distracter. The order in which the experiments were done was not randomized and therefore participants might have learned to make more efficient searches with ongoing experiments, which may explain the lack of an effect of the dual task or the addition of the colored pop out distracter. In order to test whether the consistent color of the distracter enabled learning, we repeated experiments 2 and 4 but varied the color of the pop out distracter between 10 possible colors. Similar results were found for both groups, showing the same or slightly higher (especially older group) viewing efficiency compared to their performance in Expt 2 and Expt 4. This suggests that practice plays a role in learning to disregard distracters when assessing functional field of view and may override the effect of clutter or pop out stimuli.

The study has limitations due to the small sample size and the lack of counterbalancing the conditions. Eye movements were not measured and therefore no conclusions can be drawn with respect to where participants were actually looking. It does, however, provide valuable information of how the functional field of view changes for different scenarios and the role of practice. In summary, viewing efficiency as described by AFOV is affected by age. The utilization of efficient vs. inefficient searches is suggested as the reason for the differences found between age groups. Elderly participants have more difficulty in disregarding irrelevant distracters and resort to an inefficient search strategy. Older peoples' performance in the presence of distracters is reduced by a constant amount compared to younger observers, but the addition of a dual task or a pop out distracter has little effect. An important aspect of this study is the finding that older or younger individuals are not affected significantly by the presence of the irrelevant pop out distracter. This has implications, as with ensuing trials individuals are able to ignore the pop out distracter irrespective of the location in the visual field. In situations such as driving or other situations of hazard avoidance, the presence of irrelevant pop out distracter does not impair the search performance beyond what is found with general clutter. This is encouraging, as it implies that the deficit in older people is a constant reduction, rather than increasing with increased stimulus complexity, and the practice effects suggest that reduced performance of older individuals may be trainable.

The results obtained are relevant to everyday tasks such as driving and walking. For example, a new distraction, such as a new bill board, would not be expected to affect an older individual more than their younger counterpart while driving. In the vision literature, the use of a test such as the UFOV has been suggested to identify the at-risk driver. Parameters that affect tests such as AFOV and UFOV have to be well understood before applying such tests in a real world scenario. Our experiment has highlighted how some of these parameters affect the AFOV.

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Conflicts of interest

The authors have no conflicts of interest to declare.

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