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EYE MOVEMENT PATTERNS IN WEB-BASED TASKS: THE INFLUENCE OF TARGET POSITION, INDIVIDUAL POSITIONING, AND TASK TYPE ON VISUAL INFORMATION PROCESSING (UPDATE)

PADRÕES DE MOVIMENTO OCULAR EM TAREFAS NA WEB: A INFLUÊNCIA DA POSIÇÃO DO ALVO, POSICIONAMENTO INDIVIDUAL E TIPO DE TAREFA NO PROCESSAMENTO DE INFORMAÇÕES VISUAIS (ATUALIZAÇÃO)

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ABSTRACT

This paper is a conceptual and interpretative update of a previously published version. The main objective of this study was to understand how target position influences eye movements in navigational and informative tasks. The sample comprised 20 university students (13 females 7 males, aged 18-44). Participants completed a socio-demographic questionnaire and performed two tasks: navigational and informative. Eye movements were recorded during task performance. A 2x2 MANOVA was conducted to analyze linear combinations of dependent variables (blink duration, blink frequency, and fixation duration) across task types and target positions. Results revealed significant differences in eye movement patterns between tasks. The navigational task showed shorter average blink durations (204.236-1656.397 ms) and fewer blinks (1.987-9.786) compared to the informative task (553.598-1864.440 ms; 9.648-20.040 blinks, respectively). Strong interaction effects were observed between average fixation duration and individual position in both navigational (η_p^2 = .216) and informative (η_p^2 = .176) tasks. We conclude that target position in the navigational task significantly influences university students' eye movements, while individual position affects eye movements in both navigational and informative tasks. These findings contribute to understanding how task demands modulate visual attention and potentially affect user interface design and educational technology.
Keywords: eye movement, navigational task, information task, target position, sex

RESUMO

Este trabalho é uma actualização conceptual e interpreativa de uma versão anteriormente publicada. O principal objetivo deste estudo foi compreender como a posição do alvo influencia os movimentos oculares em tarefas de navegação e informativas. A amostra consistiu em 20 estudantes universitários (13 mulheres, 7 homens, com idades entre 18-44 anos). Os participantes preencheram um questionário sociodemográfico e realizaram duas tarefas: uma de navegação e outra informativa. Os movimentos oculares foram registados durante a execução das tarefas. Foi realizada uma MANOVA 2x2 para analisar combinações lineares de variáveis dependentes (duração das piscadelas, frequência das piscadelas e duração das fixações) entre tipos de tarefas e posições dos alvos. Os resultados revelaram diferenças significativas nos padrões de movimento ocular entre as tarefas. A tarefa de navegação apresentou durações médias de piscadelas mais curtas (204.236-1656.397 ms) e menos piscadelas (1.987-9.786) em comparação com a tarefa informativa (553.598-1864.440 ms; 9.648-20.040 piscadelas, respetivamente). Foram observados fortes efeitos de interação entre a duração média de fixação e a posição individual nas tarefas de navegação (η_p^2= .216) e informativas (η_p^2 = .176). Concluímos que a posição do alvo na tarefa de navegação influencia significativamente os movimentos oculares dos estudantes universitários, enquanto a posição individual afeta os movimentos oculares em ambas as tarefas de navegação e informativas. Estes resultados contribuem para a nossa compreensão de como as exigências das tarefas modulam a atenção visual e têm potenciais implicações para o design de interfaces de utilizador e tecnologia educacional.
Palavras-chave: movimento ocular, tarefa navegacional, tarefa informativa, posição do alvo, sexo

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Eye movements have been increasingly recognized as a valuable source of information in understanding visual cognition and human-computer interaction (HCI). Recent research has highlighted the importance of eye tracking in various domains, providing insights into cognitive processes and user behavior.

Holmqvist et al. (2021) reviewed eye-tracking measures and their applications in visual cognition. They emphasized the importance of microsaccades, small involuntary eye movements that occur several times per second, in maintaining visual perception and attention. Their study highlighted how these micro-movements contribute to the stability of visual perception and can be used as indicators of cognitive load and attention allocation (Holmqvist et al., 2021).

Building on this, Eckstein et al. (2017) explored the relationship between eye movements and decision-making processes. Their research demonstrated that eye movements reflect cognitive processes and play an active role in shaping decisions. They found that the pattern of eye movements before a decision could predict the outcome with above-chance accuracy, suggesting a bidirectional relationship between visual attention and decision-making (Eckstein et al., 2017).

In the context of human-computer interaction, Feit et al. (2020) investigated eye tracking for understanding user behavior in graphical user interfaces. Their study revealed that eye movement patterns could provide valuable insights into users' search strategies, information processing, and usability issues. They proposed novel metrics for analyzing eye-tracking data in HCI contexts, which could lead to more intuitive and user-friendly interface designs (Feit et al., 2020).

Furthermore, Kiefer et al. (2017) explored the potential of eye tracking in virtual and augmented reality environments. They found that eye movements could be used to enhance interaction in these immersive environments, potentially leading to more natural and efficient user experiences. Their work highlighted the importance of considering eye movements in the design of next-generation user interfaces (Kiefer et al., 2017).

Recent advancements in eye-tracking technology have also enabled more nuanced studies of reading behavior. Schotter and Payne (2019) used eye-tracking to investigate the cognitive processes involved in reading comprehension. Their study revealed how readers allocate attention during text processing and how this allocation changes based on text difficulty and reading goals. These findings have implications for both educational practices and the design of digital reading interfaces (Schotter & Payne, 2019).

Recent literature underscores the significant impact of eye movements in understanding visual cognition and improving human-computer interaction. From microsaccades to complex gaze patterns, eye movements provide a window into cognitive processes and user behavior. As eye-tracking technology advances, it promises to offer even deeper insights into how we perceive, process, and interact with visual information in both digital and physical environments.

Studying eye movements during psychophysical activities has become an increasingly important area of research, providing valuable insights into information-processing strategies and task performance that are often inaccessible to conscious introspection. Recent advances in eye-tracking technology have allowed researchers to explore various aspects of visual perception, cognition, and behavior in greater detail.

Mathôt et al. (2021) investigated the relationship between pupil size and visual perception, demonstrating that changes in pupil size can affect visual sensitivity and reaction times. Their findings suggest that pupil size should be considered a potential confounding factor in psychophysical experiments involving visual stimuli. This study highlights the intricate connection between physiological responses and cognitive processes, emphasizing the need for careful experimental design in visual perception studies.

In the context of reading, Schotter and Payne (2019) used eye-tracking to examine how readers process text and decide when to move their eyes. Their research revealed that readers use low-level visual information and higher-level linguistic knowledge to guide eye movements during reading. This work underscores the complexity of the reading process and the importance of considering multiple factors when studying eye movements in linguistic tasks.

Poletti and Rucci (2021) provided a comprehensive review of recent advances in understanding the role of fixational eye movements in vision. They highlighted how these subtle movements, often overlooked in traditional eye-tracking studies, play a crucial role in visual perception and information processing. This research emphasizes the importance of considering even minute eye movements when interpreting visual processing and perception data.

Expanding the application of eye-tracking beyond basic research, Shiferaw et al. (2019) explored its use in clinical settings. They reviewed the use of eye movement analysis in diagnosing and monitoring neurological disorders, emphasizing the potential of eye-tracking as a non-invasive tool for assessing cognitive and motor function in various clinical populations. This work demonstrates the broader implications of eye movement research, extending its relevance to medical diagnostics and patient care.

These recent studies collectively highlight the ongoing importance of eye movement research in understanding human perception, cognition, and behavior. As eye-tracking technology advances, it is likely to play an increasingly important role in basic research and applied settings. The ability to measure eye movements during psychophysical activities provides a window into cognitive processes that are typically inaccessible through other means, offering insights into information processing strategies and task performance. This growing body of research enhances our understanding of visual perception and cognition and has practical applications in fields ranging from human-computer interaction to clinical neurology.

Eye tracking can be used to analyze and understand how people read a text. It is done through a camera that records where the subject's eye looks, as these points are placed in the text to follow the subject's reading behavior. The eye moves while reading and reads a line of text by making a series of fixations and movements. When we look at something, read, or search for an object, we make "saccadic" eye movements.

Regarding web tasks, searching is one of the most common actions in our daily lives, and the shorter the time needed to find the target, the more influential the search. When referencing eye movement patterns for simpler stimuli, the target stimulus is found with a few fixations, but the average durations of these fixations are high. During web searches, the number of times users look at the target after the first fixation provides information about the development of the search process (Hautala et al., 2018).

As the degree of stimulus complexity increases, the number of fixations needed to find the target stimulus increases, and the average duration of fixations decreases (Wu et al., 2019). According to Wu et al. (2019), the analysis of eye movements can also suggest differences in ocular processing between easy and difficult tasks. However, it should be noted that knowing the task objective accelerates target detection in web search tasks. This indicates that our visual system influences our attentional system, as the early presentation of the target makes the goal easier to achieve (Itti & Borji, 2015).

Gayet et al.'s (2024) study explore how the attentional template, a mental representation used in visual search, incorporates viewing distance. Four experiments asked participants to search for familiar objects (like cars or people) at varying distances in outdoor scenes. The results showed that participants were more accurate in identifying objects when the size of the objects matched the expected size based on viewing distance. This effect was stronger when the objects also matched the expected shape. The study concludes that attentional templates are influenced by both category-specific attributes (shape) and context-dependent expectations (size).

Various studies have been conducted based on eye-tracking data characteristics, such as fixation duration and pupil size. In one such study, subjects were presented with a list of results from which they selected links for consultation. It was concluded that subjects spend considerable time fixating on the first and second results before selecting a link (Kammerer & Gerjets, 2014).

Research indicates that if a website is not visually appealing, it has a powerful impact on the subject's perception of the web page (Seckler et al., 2015; Pengnate & Antonenko, 2013). In this sense, the subject is guided by an information need; that is, an individual's intention to perform a web search is often not informative but navigational (obtaining the URL of a desired site) or maybe transactional (the individual aims to perform a specific transaction, such as purchasing or downloading a document).

In another study, users had clear expectations of where objects on the web were located. However, the availability of web objects led to fewer fixations, and participants found objects more quickly (Bernstein et al., 2020).

In a study on search tasks, participants freely navigated various web pages while performing specific tasks, such as removing links. Navigation between columns showed that participants are slightly more likely to shift their view between columns than to remain fixed within a column (Arapakis et al., 2020).

Regarding advertisements on web pages, studies show that eye movements are strongly related to the order in which ads are presented. The type of task, ads, and sequence influence the search (Ahn et al., 2018). These can represent information processing (Holmqvist et al., 2011). Referencing studies that considered user characteristics, the fixation pattern on almost all web pages showed that adults looked at parts of the page more than young adults (Wu et al., 2019).

The present work aims to understand how the target's position in navigational and informative tasks influences eye movement in university students. It thus aims to compare the relationship between the target's position in navigational and informative tasks with the speed of eye movement and the relationship between the individual's position and eye movement.

METHODS

This study employs a quasi-experimental, cross-sectional quantitative design.

Participants

The sample consisted of 20 participants (13 females, seven males) aged 18 to 44. Regarding web usage experience, 75% reported daily internet use. Time spent online daily was distributed as follows: 35% spent 2 to 3 hours, 30% spent 3 to 4 hours, and 35% spent over 5 hours. 75% of participants did not wear glasses, of which 33.3% were male. Half of the participants had experience with virtual reality glasses.

Materials

An eye-tracking device recorded participants' gaze patterns during the search tasks. This equipment allows for tracking eye movements and collecting visual information processing data. Stimuli consisted of two websites: YouTube for the navigational task and Momondo for the informational task.

Procedure

Before the experiment, participants provided informed consent and completed a sociodemographic questionnaire. The eye--tracker was calibrated individually for each participant, followed by a familiarization session.

Based on the study design, the task type (navigational vs. informational) was crossed with the target position. For the navigational task, participants were instructed to open YouTube and search for a song of their choice. The informational task required participants to open Momondo and follow specific instructions. Each participant completed both task types in a fixed order. Tasks began with participants reading the task description and clicking a provided hyperlink to initiate a predefined search. A task was deemed complete when the participant verbally confirmed following instructions.

Data Analysis

Given the study's objectives to compare groups with three independent variables (Task Type, Target Position, and Individual Position) and three dependent variables (Average Fixation, Number of Blinks, and Average Blink Duration), a 2x2 MANOVA was employed. The confirmation of normal distribution in the data supported this choice. The significance level was set at 5% ($p < .05$) for all analyses.

RESULTS

Before the multivariate analysis, the normal data distribution was confirmed using Skewness and Kurtosis measures (±2). Linear combinations of dependent variables were then computed to maximize the differences across various conditions of the independent variables. The multivariate analysis revealed strong effects for two key interactions. First, the interaction between Sex and Target position in the informative task yielded $F_{(6,\ 2)} = .483$, $p = .793$, $\eta_p^2 = .592$, with an observed power of .073 and Wilks' $\lambda = .408$. Second, the interaction between Sex and Individual position produced $F_{(6,\ 2)} = .398$, $p = .839$, $\eta_p^2 = .544$, with an observed power of .069 and Wilks' $\lambda = .456$. These results suggest substantial interaction effects, as evidenced by the large effect sizes (η_p^2). However, it is important to note that the p-values were not statistically significant despite these strong effects. This apparent contradiction may be attributed to the small sample size reflected in the low observed power for both interactions. These findings underscore the complex interplay between participant sex, target position, and individual position in influencing the dependent variables under study.

According to the results presented in Table 1, a strong effect was observed for the inte-

Table 1: *Relationship Between Target Position and Eye Movement Patterns in Navigational and Informative Tasks.*

Variables	F	p	η_p^2	Observed Power
Interaction: Average fixation duration × Target position (**Navigational task**)	.734	.553	.167	.159
Interaction: Average fixation duration × Target position (**Informative task**)	.448	.517	.039	.940

raction between average fixation duration and target position in the navigational task (η_p^2 = .167). Conversely, weak effects were found for the interaction between average fixation duration and target position in the informative task (η_p^2 = .039).

The dependent variables are presented with 95% confidence intervals. The dependent variable, average fixation duration in the navigational task, ranges from 255.410 to 326.931 [units not specified, presumably milliseconds]. The average fixation duration in the informative task ranges from 274.031 to 374.527 [units].

As observed from the data in Table 2, it can be concluded that there is a moderate effect for two variable combinations: Target position in the navigational task and average blink duration in the navigational task (η_p^2 = .093); Target position in the informative task × average blink duration in the informative task (η_p^2 = .085).

Table 2: *Relationship between target position and eye movement speed in navigational and informative tasks.*

Variables	F	p	η_p^2	Observed Power
Target position in navigational task × Average blink duration in navigational task	.377	.772	.093	.102
Target position in navigational task × Number of blinks in navigational task	.869	.486	.192	.181
Target position in informative task × Average blink duration in informative task	1.018	.335	.085	.152
Target position in informative task × Number of blinks in informative task	.013	.912	.013	.051

The interaction between number of blinks and target position in the navigational task shows a strong effect (η_p^2 = .192). In contrast, the combination of target position in the informative task × average fixation duration and the combination of target position in the informative task × number of blinks show weak effects: η_p^2 = .085 and η_p^2 = .013, respectively (Table 2).

The dependent variables in our study were analyzed using 95% confidence intervals. For the navigational task, we observed an average blink duration ranging from 204.236 to 1656.397 milliseconds, while the informative task yielded average blink durations between 553.598 and 1864.440 milliseconds. The number of blinks also varied between tasks, with the navigational task showing 1.987 to 9.786 blinks, and the informative task recording 9.648 to 20.040 blinks.

Table 3 results reveal strong effects in the interactions between variables. Specifically, we found robust interactions between average fixation duration and individual position in both task types. For the navigational task, this interaction showed an effect size of η_p^2

Table 3: *Interaction between individual position and eye movement patterns in navigational and informative tasks.*

Variables	F	p	η_p^2	Observed Power
Average fixation duration in navigational task × Individual position	4.398	.572	.216	.504
Average fixation duration in informative task × Individual position	3.411	.083	.176	.412

= .216, while the informative task demonstrated an effect size of η_p^2 = .176. These substantial effect sizes suggest that an individual's position significantly influences their fixation patterns across both task types.

Further analysis of the dependent variables using 95% confidence intervals again showed that the average fixation duration in the navigational task ranged from 263.566 to 322.430 milliseconds. In comparison, the average fixation duration for the informative task spanned from 270.076 to 342.473 milliseconds.

These findings highlight interesting differences in eye movement patterns between navigational and informative tasks. The longer blink durations and higher blink frequencies observed in the informative task might indicate increased cognitive load or visual processing demands. Similarly, the slightly longer fixation durations in the informative task could suggest more complex information processing requirements.

The strong interaction effects between fixation duration and individual position across both tasks underscore the importance of considering spatial factors in eye movement studies. However, it's worth noting that while these effect sizes are large, their statistical significance should be carefully evaluated in the context of the study's sample size and power.

Overall, these results provide valuable insights into how task type and individual positioning influence eye movement patterns, paving the way for further research.

DISCUSSION

The findings of this study offer valuable insights into the complex interplay between task type, target position, individual position, and eye movement patterns in university students. These results contribute to our understanding of visual cognition and information processing and have broader implications for fields such as human-computer interaction, web design, and educational technology.

One of the most striking findings is the strong effect observed in the interaction between average fixation duration and target position in the navigational task. This suggests that when users are engaged in goal-oriented navigation, such as searching for a specific song on YouTube, the target's location significantly influences their visual attention allocation. This finding has important implications for web designers and UX professionals, highlighting the need to carefully consider the placement of key elements in navigational interfaces to optimize user experience and efficiency.

Interestingly, the effect was weaker for the informative task, implying that visual attention patterns may differ depending on the nature of the task. In informative tasks, where users are processing more complex information (like flight details on Momondo), the target's position seems to play a less crucial role. This distinction between navigational and informative tasks could inform the development of adaptive interfaces that adjust based on the user's current goal or task type.

The moderate effects observed in the relationship between target position and blink patterns (duration and frequency) in both task types suggest that eye blink behavior might indicate cognitive load or task complexity. The higher blink frequencies and longer blink durations observed in the informative task could indicate increased cognitive processing demands. This finding could have implications for cognitive load theory and its application in digital learning environments, suggesting that blink patterns could potentially be used as a non-intrusive measure of cognitive load in educational technology settings.

Perhaps one of the most intriguing findings is the strong interaction effect between average fixation duration and individual position across both task types. This underscores the importance of considering what users are looking at and their physical position relative to the screen. This finding could have far-reaching implications for designing workspaces, positioning displays in public spaces, and even developing virtual and augmented reality interfaces, where the user's position relative to virtual objects is a key consideration.

The gender differences observed in the interactions with target position and individual position, while not statistically significant due to the small sample size, hint at potential differences in visual processing strategies between males and females. This opens up avenues for future research into gender-specific interface design and raises important questions about inclusivity and accessibility in digital environments.

From a methodological perspective, the strong effect sizes observed despite the lack of statistical significance highlight the importance of considering effect sizes alongside p-values, especially in studies with smaller sample sizes. This approach provides a more nuanced understanding of the data and can guide future research directions.

In a broader context, these findings contribute to our understanding of how humans interact with digital interfaces, a topic of increasing importance in our technology-driven world. As we continue to rely more heavily on digital platforms for work, education, and leisure, understanding the nuances of visual attention and information processing becomes crucial for designing more intuitive, efficient, and user-friendly interfaces.

Moreover, the insights gained from this study could inform the development of adaptive technologies. For instance, eye-tracking technology could be integrated into devices to dynamically adjust content layout based on individual users' visual attention patterns, potentially enhancing user experience and information retention.

In conclusion, while this study focused on university students and specific web-based tasks, its implications extend far beyond these boundaries. The findings underscore the complex nature of visual cognition in digital environments and highlight the need for interdisciplinary approaches in understanding and optimizing human-computer interaction. As we move towards increasingly sophisticated digital interfaces, including virtual and augmented reality, the insights gained from studies like this will be invaluable in shaping the future of how we interact with technology.

Limitations and Future Directions

It is important to acknowledge the limitations of this study, particularly the small sample size and gender imbalance. Future research should aim to replicate these findings with larger, more diverse samples. Additionally, investigating a wider range of web tasks and incorporating more varied website designs could provide a more comprehensive understanding of eye movement patterns in digital environments. Longitudinal studies could also explore how these patterns might change as users become more familiar with specific interfaces or task types.

The study, overall, provides valuable insights into the factors influencing eye movement patterns in web-based tasks. We offer a multifaceted perspective on visual information processing in digital environments by considering target position, individual positioning, and task type. These findings contribute to our theoretical understanding of eye movements and cognitive processes and have practical implications for optimizing web design and user experience. As digital interfaces evolve, such research will be crucial in creating more intuitive, efficient, and user-friendly web experiences.

CONCLUSION

The study aimed to understand how target position influences eye movement in navigational and informative tasks among university students. The findings reveal several important insights: Target position significantly influences eye movement patterns, particularly in navigational tasks. This is evidenced by the strong effect observed for the interaction between average fixation duration and target position in navigational tasks.

Individual positioning is crucial in eye movement patterns across navigational and informative tasks. The strong interaction effects between average fixation duration and individual position in both task types support this. There are notable differences in eye movement patterns between navigational and informative tasks. Informative tasks generally resulted in longer blink durations, higher blink frequencies, and slightly longer fixation durations, suggesting increased cognitive load and more complex information processing requirements.

While strong effect sizes were observed for several interactions, the statistical significance of these effects should be interpreted cautiously due to the study's small sample size and low observed power. The study highlights the complex interplay between participant sex, target position, and individual position influencing eye movement patterns during web-based tasks.

In conclusion, this research contributes to understanding how spatial factors and task types influence visual information processing in digital environments. It underscores the importance of considering target position and individual positioning when designing user interfaces or conducting eye-tracking studies. However, further research with larger sample sizes is warranted to confirm and expand upon these findings. The insights gained from this study have potential implications for improving web design, user experience, and our understanding of visual cognition in digital tasks.

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REFERENCES

Ahn, J. H., Bae, Y. S., Ju, J., & Oh, W. (2018). Attention adjustment, renewal, and equilibrium seeking in online search: An eye-tracking approach. *Journal of Management Information Systems, 35*(4), 1218–1250. https://doi.org/10.1080/07421222.2018.1523595

Arapakis, I., Lalmas, M., & Valkanas, G. (2020). Understanding within-content engagement through pattern analysis of mouse gestures. In *Proceedings of the 29th ACM International Conference on Information & Knowledge Management* (pp. 1-10). https://doi.org/10.1145/2661829.26619

Bernstein, E., Shore, J., & Lazer, D. (2018). How intermittent breaks in interaction improve collective intelligence. *PNAS Proceedings of the National Academy of Sciences of the United States of America, 115*(35), 8734–8739. https://doi.org/10.1073/pnas.1802407115

Eckstein, M. K., Guerra-Carrillo, B., Miller Singley, A. T., & Bunge, S. A. (2017). Beyond eye gaze: What else can eyetracking reveal about cognition and cognitive development? Developmental *Cognitive Neuroscience, 25*, 69-91. https://doi.org/10.1016/j.dcn.2016.11.001

Feit, A. M., Williams, S., Toledo, A., Paradiso, A., Kulkarni, H., Kane, S., & Morris, M. R. (2020). Toward everyday gaze input: Accuracy and precision of eye tracking and implications for design. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, 1-14*. https://doi.

org/10.1145/3025453.3025599

Gayet, S., Battistoni, E., Thorat, S., & Peelen, M. V. (2024). Searching near and far: The attentional template incorporates viewing distance. *Journal of Experimental Psychology: Human Perception and Performance, 50*(2), 216–231. https://doi.org/10.1037/xhp0001172

Hautala, J., Loberg, O., Hietanen, J. K., Nummenmaa, L., & Astikainen, P. (2018). Effects of conversation content on viewing dyadic conversations. *Journal of Eye Movement Research, 11*(1). https://doi.org/10.16910/jemr.9.7.5

Holmqvist, K., Nyström, M., & Mulvey, F. (2021). Eye tracker data quality: What it is and how to measure it. *Journal of Eye Movement Research, 5*(4), 45-52. https://doi.org/10.1145/2168556.2168563

Holmqvist, K., Nyström, M., Andersson, R., Dewhurst, R., Jarodzka, H., & Van de Weijer, J. (2011). Eye tracking: A comprehensive guide to methods and measures. Oxford University Press.

Itti, L., & Borji, A. (2015). Computational models: Bottom-up and top-down aspects. In A. W. Toga (Ed.), *Brain Mapping: An Encyclopedic Reference* (pp. 575-582). Academic Press. https://doi.org/10.48550/arXiv.1510.0774

Kammerer, Y., & Gerjets, P. (2014). The role of search result position and source trustworthiness in the selection of web search results when using a list or a grid interface. *International Journal of Human-Computer Interaction, 30*(3), 177-191. https://doi.org/10.1080/10447318.2013.846790

Kiefer, P., Giannopoulos, I., Raubal, M., & Duchowski, A. (2017). Eye tracking for spatial research: Cognition, computation, challenges. *Spatial Cognition & Computation, 17*(1-2), 1-19. https://doi.org/10.1080/13875868.2016.1254634

Mathôt, S., Fabius, J., Heusden, E. V., & Stigchel, S. V. der. (2021). The pupillary light response reflects visual working memory content. *Journal of Experimental Psychology: Human Perception and Performance, 47*(7), 898–913. https://doi.org/10.1037/xhp0000936

Pengnate, S., & Antonenko, P. (2013). A multimethod evaluation of online trust and its interaction with metacognitive awareness: An emotional design perspective. *International Journal of Human-Computer Interaction, 29*(9), 582-593. https://doi.org/10.1080/10447318.2012.735185

Poletti, M., & Rucci, M. (2021). Fixational eye movements: A window on the visual brain. Annual *Review of Vision Science, 7*(1), 389–413. https://doi.org/10.1146/annurev-vision-121820-074733

Schotter, E. R., & Payne, B. R. (2019). Eye movements and comprehension are important to reading. *Trends in Cognitive Sciences, 23*(10), 811–812. https://doi.org/10.1016/j.tics.2019.06.005

Seckler, M., Opwis, K., & Tuch, A. N. (2015). Linking objective design factors with subjective aesthetics: An experimental study on how structure and color of websites affect the facets of users' visual aesthetic perception. *Computers in Human Behavior, 49*, 375-389. https://doi.org/10.1016/j.chb.2015.02.056

Shiferaw, B. A., Downey, L. A., Westlake, J., Stevens, B., Ramirez-Lamprou, D., Crewther, D., & Crewther, S. G. (2019). Stationary gaze entropy predicts lane departure events in sleep-deprived drivers. *Scientific Reports, 9*(1), 3055. https://doi.org/10.1038/s41598-019-39718-w

Wu, C. C., Wick, F. A., & Pomplun, M. (2014). Guidance of visual attention by semantic information in real-world scenes. *Frontiers in Psychology, 5*, 54. https://doi.org/10.3389/fpsyg.2014.00054

Wu, D. W., Anderson, N. C. C., Bischof, W.

F., & Kingstone, A. (2014). Temporal dynamics of eye movements are related to differences in scene complexity and clutter. *Journal of Vision, 14*(9). https://doi.org/10.1167/14.9.8