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BICA VPS 2023

Identification of Ambient and Focal Information Processing Phases Using Eye Movement Response Registration.

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SUMMARY

Using the EyeLink 1000 Plus eye tracker and machine learning, we studied attention types in 10 participants viewing room interiors. We found that ambient attention results in quick, non-specific fixations, while focal attention leads to longer fixations on key objects. These findings can enhance Brain-Computer Interface (BCI) and Eye-Brain-Computer Interface (EBCI) technologies, with potential impacts on neuroscience and user interface design.

INTRODUCTION

Attention, a multi-level process in cognitive psychology, encompasses two primary types: ambient and focal. **Ambient attention** broadly distributes attentiveness across stimuli, aiding in spatial navigation and reaction speed. In contrast, **focal attention** focuses on recognizing individual objects, invoking prior experiences and specific social cognition.

Eye tracking technology offers insights into these attention types by pinpointing gaze direction. Our goal is to harness this technology, developing algorithms to discern dominant attention mechanisms, facilitating a deeper exploration of attention dynamics and cognitive functions

APPROACH

We used the EyeLink 1000 Plus system with active pupil registration to record eye movements at a speed of up to 1000 fps. Stimuli comprised pictures of room interiors presented via the Presentation software. 10 participants (average age: 26 ± 3.4 years) first examined 20 images, focusing on a fixation cross between them, followed by a recognition test using a button block. This cycle was repeated twice, with rest intervals.

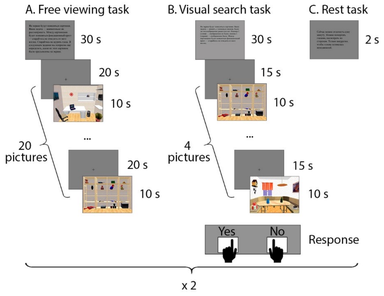

Fig 1. Experiment scheme

METHODS

We analyzed fixations, stable gaze periods, to identify attention concentration. Ambient attention is marked by rapid, non-specific fixations, while focal attention involves slower, object-focused fixations. Our approach segmented fixations by interest area, speed, and duration.

RESULTS

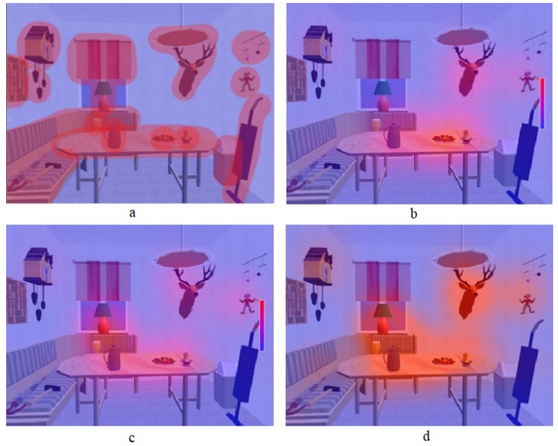

Fig 1. Results: a) fixation segmentation by areas of interest, b) fixation segmentation by speed, c) fixation segmentation by duration, d) classification

ANALYSIS

1. **Fixation Processing**:
   - Analyzed fixations for attention concentration.
   - Segmented by interest areas, speed, and duration.
   - Used Markov chain for sequence representation.
2. **Speed Segmentation:**
   - Converted coordinates to speed sequences.
   - Estimated overall fixation speed.
3. **Duration Segmentation:**
   - Evaluated fixation durations from 40 ms to 2 s.
   - Applied Otsu method for thresholding.
4. **Classification:**
   - Classified fixations into ambient or focal attention.
   - Used statistical thresholds considering individual variances.

DISCUSSION

We segmented fixations based on specific parameters, classifying them into ambient or focal attention types. Using fMRI data as a reference, we achieved accurate classification. Each gaze movement type exhibited distinct features, enabling us to simplify the classification process by converting eye movement sequences into fixed-length feature vectors.

CONCLUSIONS

1. Our research successfully segmented and classified fixations based on their attention type.
2. The unique characteristics of gaze movements were identified, streamlining the classification process.
3. This study is a foundational step in a broader project on understanding attention mechanisms and their cognitive implications, with plans for deeper exploration.

ACKNOWLEDGMENTS

The work was carried out within the framework of the state assignment of the National Research Center «Kurchatov Institute»