eego™sports

ultra-mobile EEG & EMG recording solution

Showcase:

Investigating the impact of auditory navigation instructions upon incidental spatial learning in pedestrians

Published: July 2020

SLS-SM-0211rev01 - DRN-SLS-06816.02

ant neuro
inspiring technology

Investigating the impact of auditory navigation instructions upon incidental spatial learning in pedestrians

Professor Klaus Gramann *is the Head of the Department of Biological Psychology and Neuroergonomics at the Berlin Institute of Technology in Berlin, Germany, and founder of the Berlin Mobile Brain / Body Imaging Lab (BeMoBIL). He is also on the International Faculty at School of Software, University of Technology Sydney, Australia, and at the Center for Advanced Neurological Engineering, University of California, San Diego.*

Anna Wunderlich *is a PhD student at BeMoBIL, whose work focuses on identifying neural and behavioral processes underlying natural cognition. She obtained her Masters degree in Human Factors at TU Berlin in 2016 and Bachelors degree in Sensoric and Cognitive Psychology at TU Chemnitz in 2013. Hereafter, she joined the laboratory of Prof. Klaus Gramann in 2017 as a PhD candidate. Her thesis focuses on spatial knowledge acquisition during assisted navigation comparing landmark-based and standard navigation instructions.*

Introduction

Smartphones have become a standard utensil in the vast majority of everyone's daily life. Importantly, it has become rather customary to employ smartphones when having to navigate within novel environments. In fact, Navigation Assistance Systems (NAS) are used extensively by pedestrians and vehicle operators alike. While this technological revolution provides a remarkable tool for everyday spatial exploration, there has been a growing body of work focusing on the impact of NAS upon perception and interaction with the environment. More specifically, Wunderlich and colleagues aim at investigating the impact of NAS on the neurophysiological mechanisms underpinning spatial cognition in general and incidental spatial learning in particular.

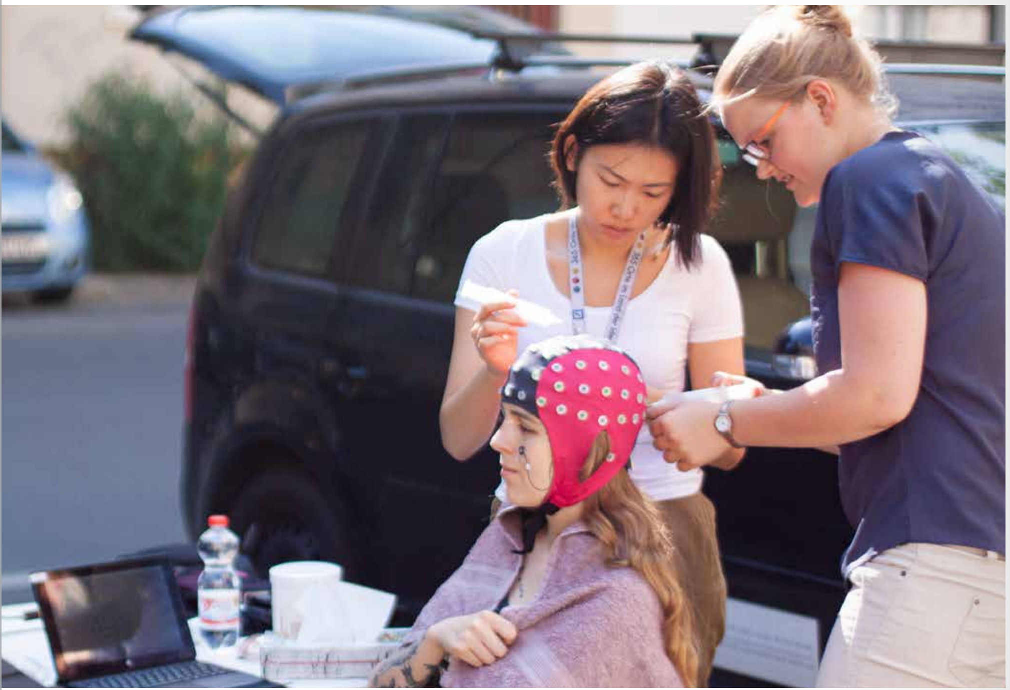
The interest of the BeMoBIL to further explore the impact of NAS on spatial cognition was driven by prior studies suggesting that excessive use of NAS technology leads to a decrease of orienting abilities *(Münzer, Zimmer, Schwalm, Baus, & Aslan, 2006)*. In fact, several studies have shown that the use of visual-based NAS interferes with visuo-motor spatial processing during navigation (resulting in an automation bias) due to the increase in attentional demands *(e.g . Lin, Kuehl, Schöning, & Hecht, 2017)*. Ultimately, this results in the over-reliance on the NAS by the user in order to cope with the increased cognitive demands and, consequently, to diminished spatial processing *(Fenech, Drews, & Bakdash, 2010)*.

Interestingly, auditory-based NAS seem to be beneficial for spatial navigation, and to interfere less with visuo-motor processes (*May & Ross, 2006; Wunderlich & Gramann, 2018)*. Further, Gramann and colleagues (2017) showed that auditory navigation instructions could improve incidental spatial learning when landmarks were augmented in a virtual driving task *(Gramann, Hoepner, & Karrer-Gauss, 2017, Wunderlich & Gramann, 2018)*. Here, Wunderlich and Gramann investigated how auditory NAS instructions affect spatial navigation and subsequent spatial memory trace retrieval within real-world settings.

Premise

The findings from Gramann and colleagues (2017, 2018) provided initial and compelling results suggesting beneficial incidental learning effects following enhanced auditory navigation instructions. Nonetheless, these data were acquired within a controlled laboratory setup. Whether these findings can be directly transposed to real-world settings was still to be addressed.

Figure 1 Subject preparation.



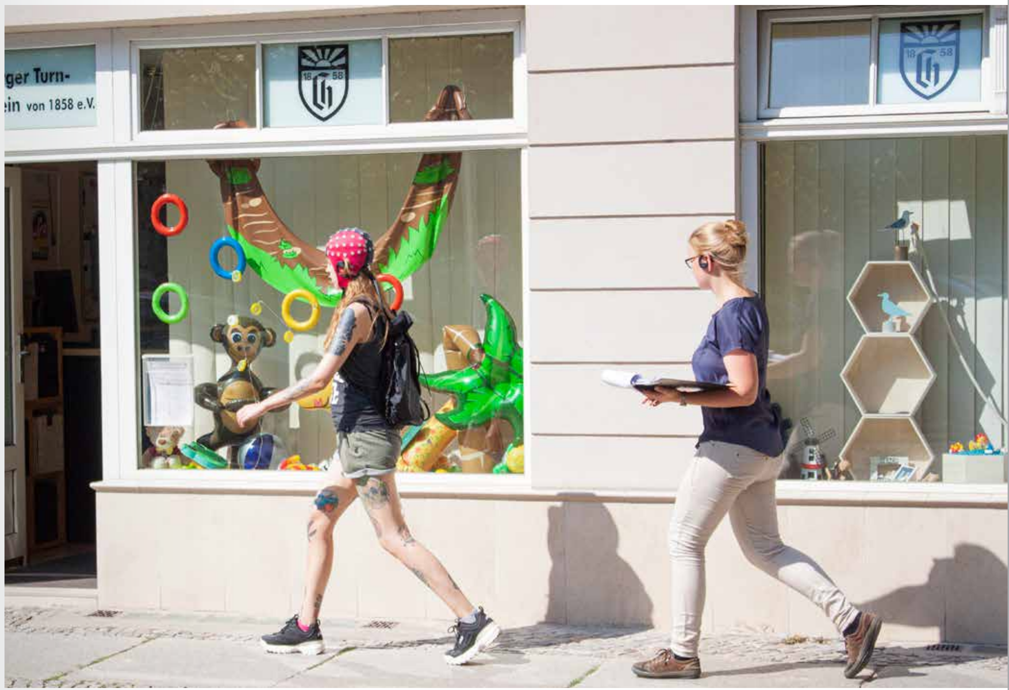
Materials & Methods:

22 participants were asked to navigate through a novel environment by following auditory navigation instructions. While participants followed a pre-defined path, simultaneous EEG from 64 channels was recorded *(see Figures 1 and 2)*.

Participants were sub-divided into two groups. While one group received *standard* navigational instructions, subjects in the second group received *long*, more detailed auditory instructions. More specifically, subjects in the standard group were prompted to (e.g.) “Turn left at the next intersection”. Alternatively, subjects in the *long* instruction group received landmark-based instructions such as “Turn left at the UdK. The UdK is the biggest University of Arts in Europe.”

Upon completion of the pedestrian route, all participants were brought back to the BeMoBIL where they were asked to draw a map and complete a cued-recall task. The latter entailed that the subjects were asked to indicate route directions according to images of landmarks. These landmarks could 1) be novel items, 2) have been encountered during straight segments of the route, or 3) have been encountered at intersections of the route.

Figure 2 Mobile EEG recording



Results

The results replicated prior findings, suggesting that landmark-based navigation instructions enhance incidental spatial learning *(Gramann et al., 2017; Wunderlich & Gramann, 2018).*

Interestingly, the results also suggested that the more detailed content presented to the "long instruction" group, significantly increase subsequent landmark recognition performance. These differences observed at the behavioral level were also reflected at the neurophysiological level. In fact, blink-related responses during navigation showed greater amplitudes over frontal electrodes as compared to standard navigation instructions.

New avenues for data processing

Importantly, the work from Wunderlich and colleagues provides exemplar insight into the analytical challenges related to EEG data acquired in real-world settings. Specifically, the present study was conducted in freely-moving participants navigating within the real world. Compared to classical laboratory-based paradigms, where analysis pipelines capitalize upon the extraction of epochs based on well-controlled events/triggers in time, no such stimulus control was applied within the paradigm at hand. Consequently, the analysis of such data poses a technical and methodological challenge.

Rather, EEG segments were extracted with respect to Eyeblinks (*b*ERPs) or saccades (*s*ERPs). The rationale behind this approach is that, in the absence of controlled visual stimulus presentations, eyeblinks and saccades can be considered as natural indices for the onset of novel information delivered to the visual system.

For a full account of the methods employed we would like to refer you to *Wunderlich & Gramann (2020).*

Outlook

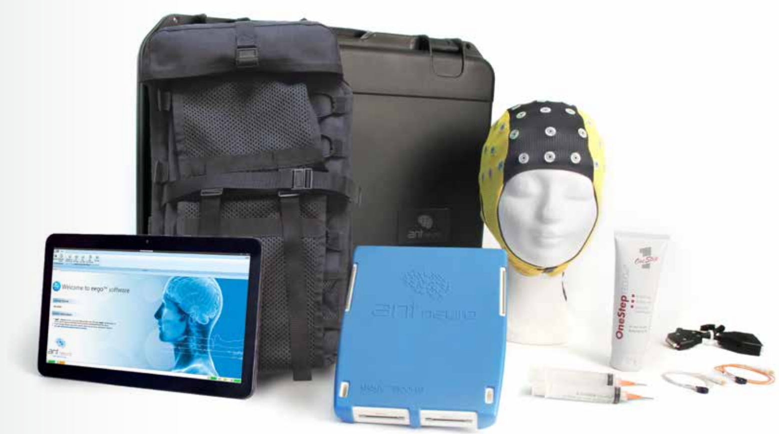
Studies such as the here presented work by Wunderlich and colleagues can further our understanding of how the brain integrates and processes information in real-world settings. This is of crucial importance when trying to bridge the gap between findings stemming from laboratory settings to the neurophysiological underpinnings of real-world exploration.

The striking advancements made in recent years within the field of hardware engineering have provided researchers with the necessary tools to acquire high-quality electroencephalographic data within real-world settings. As such, ANT Neuro is proud to contribute to such enticing research avenues through the provision of high-density EEG systems for mobile data acquisition.

Overcoming challenges of EEG recordings in Real-World settings

The investigation of neurophysiological processes in real-world settings has long-time been a major limitation factor for cognitive neuroscientists. This mainly stemmed from the lack of the availability of portable, light-weight, high-density EEG systems. Additionally, noise contamination of the EEG signal through ambient electromagnetic interference as well as mechanically induced noise transients (e.g. cable displacement) have long-time hindered a straight-forward translation of EEG setups from the laboratory into the real-world. Ultimately, the availability of analysis pipelines and computational tools, capable of effectively extracting neural activity from concurrently elicited physiological signals (e.g. muscle activity) has been a milestone within the past years.

The ANT Neuro **eego**™sports solution employed here, provides a ultra-light 64-channel amplifier which conveniently fits into a dedicated backpack. Data were recorded throughout the length of the task on a high-performance tablet placed within the backpack. Furthermore, the active shielding technology implemented between the **eego**™ amplifier and the **wave**guard™ original 64-channel electrode caps effectively counteracted interference of electromagnetic and mechanical noise sources. The current study underlines the effectiveness and outstanding EEG signal quality which can be achieved with the ANT Neuro **eego**™sports solution.



eego sports
- ultra-mobile EEG & EMG recording solution

External Links

BeMoBIL lab website : https://blogs.tu-berlin.de/bpn_bemobil/
ANT Neuro website : https://www.ant-neuro.com/
eego™ sports information : https://www.ant-neuro.com/products/eego_sports
waveguard™ original caps : https://www.ant-neuro.com/products/waveguard_original

References

Fenech, E. P., Drews, F. A., & Bakdash, J. Z. (2010). The Effects of Acoustic Turn-by-turn Navigation on Wayfinding. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 54(23), 1926–1930. https://doi.org/10.1177/154193121005402305

Gramann, K., Hoepner, P., & Karrer-Gauss, K. (2017). Modified navigation instructions for spatial navigation assistance systems lead to incidental spatial learning. Frontiers in Psychology, 8(FEB). https://doi.org/10.3389/fpsyg.2017.00193

Lin, A. Y., Kuehl, K., Schöning, J., & Hecht, B. (2017). Understanding “Death by GPS”: A Systematic Study of Catastrophic Incidents Associated with Personal Navigation Technologies. Dl.Acm.Org, 2017-May, 1154–1166. https://doi.org/10.1145/3025453.3025737

May, A. J., & Ross, T. (2006). Presence and quality of navigational landmarks: Effect on driver performance and implications for design. Human Factors, 48(2), 346–361. https://doi.org/10.1518/001872006777724453

Münzer, S., Zimmer, H. D., Schwalm, M., Baus, J., & Aslan, I. (2006). Computer-assisted navigation and the acquisition of route and survey knowledge. Journal of Environmental Psychology, 26(4), 300–308. https://doi.org/10.1016/j.jenvp.2006.08.001

Wunderlich, A., & Gramann, K. (2018). Electrocortical evidence for long-term incidental spatial learning through modified navigation instructions. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 11034 LNAI, 261–278. https://doi.org/10.1007/978-3-319-96385-3_18

Wunderlich, A., & Gramann, K. (2020). Eye-movement related brain potentials during assisted navigation in real-world environments. European Journal of Neuroscience. doi:10.1111/ejn.15095

ANT Neuro b.v., Hengelo, The Netherlands,
tel: +31 (0) 850 498 175, fax: +31 (0) 850 493 919,
internet: www.ant-neuro.com, e-mail: info@ant-neuro.com

www.ant-neuro.com

ant neuro
inspiring technology

SLS-SM-0211rev01 - DRN-SLS-06816