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Method and theory in their interplay: Using eye-tracking for investigating mathematical learning

In this presentation, we discuss the interplay between theory and one particular method of data collection: eye-tracking. Eye-tracking promises various opportunities for research, in particular for studying students' attention, strategies, and even collaboration in so-called dual eye-tracking (DUET), and has gained increased interest as a research method. Still, researchers acknowledge that eye-tracking data interpretation is difficult and ambiguous and often needs to be complemented with other sources. In this talk, we discuss two studies in which we aimed for a triangulation of eye-tracking with other research methods. In both studies, ontological and epistemological questions are intertwined.

In our first contribution, we challenged the so-called “eye-mind” hypothesis (EMH, Just & Carpenter, 1980), which posits that a person's eye movements are tightly related to their cognitive or mental processes. We see that researchers often tacitly adopt the EMH, assuming that eye movements reflect students' thinking, strategies, or cognitive/mental processes. However, we see a lack of theory use and of theory discussion in ET research: First, epistemological assumptions on whether and to what extent a psychological conceptualization of mental or cognitive processes is underlying or what other epistemological assumptions studies are based on (e.g., embodied cognition) is seldom addressed. Second, the kind of relation between eye-movements and what they may reflect (cognitive or mental processes) is generally not addressed in ET studies: Studies often implicitly assume a one-to-one correspondence between eye movements and cognitive processes even though it is known that the EMH does not always hold (Holmqvist et al., 2011). In order to investigate to what extent the EMH holds and what mental processes students' eye movements may reflect, we conducted a qualitative stimulated recall interview where a student watched the gaze-overlaid video of his work on a mathematical task. Results from this study indicated that the EMH does not always hold and confirmed that there is no one-to-one correspondence between students' eye movements and their cognitive processes. Still, the study gave hints on how eye movements may be interpreted (Schindler & Lilienthal, 2017)—even when the EMH does not hold. In particular, interpretation of particular eye movement patterns may serve as a springboard for domain-specific interpretation theories.

Our second contribution, a DUET study, follows a Vygotskyan notion of learning and development where the individual and the social are regarded dialectically interrelated (Lilienthal & Schindler, 2017). Data included not only two students' eye movements but also their gestures and oral communication. In this study, two students worked collaboratively on a mathematical problem both wearing eye-tracking glasses that also recorded sound and a video of the scene. Results indicate that students' gestures, such as pointing on the figure or verbal communication, may promote students'

joint attention. Still, our study illustrates that oral communication does not necessarily contribute to shared (visual) attention and gives a glimpse of promoting factors as well as different phases of collaboration. This study illustrates that eye-tracking may be a beneficial additional source for studying student collaboration.

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