The Trouble with Reverse Inference:
On the Mapping between Decision Processes and Movement Dynamics

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Many traditional and contemporary psychological research methods aim to measure unobservable cognitive constructs or processes by using observable proxies, such as neural activity or simply behavior. The same principle applies to more sophisticated process-tracing methods that promise more direct access to the unobservable cognitive processes. All of these methods apply a reverse inference from the measured proxies to the cognitive constructs or processes. In the realm of process-tracing methods, this reverse inference has been identified as invalid due to its logical structure. However, despite this criticism, the reverse inference additionally builds on a potentially problematic, implicit, a priori assumption, namely, that an unobservable cognitive process produces a relatively specific observable data pattern, suggesting a close mapping between the unobservable and observable processes. In this dissertation, I scrutinize the mapping between the unobservable cognitive processes and the observable data patterns, and I show that the implicit, a priori assumption of the reverse inference is indeed problematic and requires independent inquiry.

Vicariously, I examine decision-making using process-tracing methods and investigate how decision processes map onto eye and mouse cursor movements. To that end, in two studies (Chapters 2 & 5), I used a forward-inference approach to common decision-making tasks in both preferential and perceptual choice contexts, assessing how eye and mouse cursor movements reflected the decision processes participants were instructed to use. For the eye movements measured in a risky choice task (Chapter 2) and the cursor movements measured in a dot motion task (Chapter 5), the results indicate that the mapping of preferential and perceptual decision processes onto eye and cursor movements disagrees with contemporary theory in both domains. In two other studies (Chapters 3 & 4), I investigated potential factors that influence the relationship between decision processes and mouse cursor movements. I conducted a small-scale meta-analysis on how procedural characteristics of experimental tasks influence the mapping and systematically reviewed the cursor-tracking literature, collecting a representative sample of cursor-tracking tasks and their procedural characteristics (Chapter 3). I also conducted an experimental study examining how different procedures commonly used in cursor-tracking paradigms influence the mapping in an intertemporal choice task (Chapter 4). The results of these two studies indicate that the mapping of decision processes onto cursor movements is sensitive to the experimental procedure

implemented in the respective task. In sum, my research suggests that the validity of the reverse inference from eye and cursor movements onto decision processes may be substantially compromised due to incorrect, a priori assumptions about the mapping. As a potential solution, my research demonstrates that the forward-inference framework is a promising tool to independently scrutinize assumptions about the mapping in itself or across experimental procedures. In this context, my research further highlights that this process may benefit from reporting guidelines and standardization of research paradigms.

Since the issue of incorrect, a priori assumptions about the mapping is not limited to process tracing but applies to all cognitively oriented psychological research, I position my findings in the broader context of current discussions in psychological science. I propose that the predominant, cognitivist paradigm is closely related to both two psychometric issues—measurement model and construct validity—and two methodological issues—replication and heterogeneity—eventually leading to severe consequences for explanation and generalization in psychological science. However, the good news is that resolving this hitherto underappreciated problem of the reverse inference in psychological science with independent inquiry may contribute to current reforms in the field and eventually to a more robust and credible psychological science.