Tracking memory processes during ambiguous symptom processing in sequential diagnostic reasoning

Scholz, Agnes; Krems, Josef F; Jahn, Georg

Posted at the Zurich Open Repository and Archive, University of Zurich
ZORA URL: https://doi.org/10.5167/uzh-136039
Published Version

Originally published at:
Tracking memory processes during ambiguous symptom processing in sequential diagnostic reasoning

Agnes Scholz (agnes.scholz@psychologie.tu-chemnitz.de)\textsuperscript{a}
Josef F. Krems (josef.krems@psychologie.tu-chemnitz.de)\textsuperscript{a}
Georg Jahn (jahn@imis.uni-luebeck.de)\textsuperscript{b}

\textsuperscript{a}Cognitive and Engineering Psychology, Wilhelm-Raabe-Str. 43, 09120 Chemnitz, Germany
\textsuperscript{b}Institute for Multimedia and Interactive Systems, Ratzeburger Allee 160, 23562 Lübeck, Germany

\textbf{Keywords:} eye movements; process tracing; memory indexing; diagnostic reasoning; belief updating

In sequential diagnostic reasoning multiple pieces of information have to be combined to find a best explanation for observed symptoms (e.g., Johnson & Krems, 2001). Tracking memory processes involved in reasoning proves difficult because they proceed without accompanying actions towards the environment. However, this is important in order to build and test cognitive models (Schulte-Mecklenbeck, Kühberger, & Ranyard, 2011). Memory indexing is a novel method to study the time course of information processing in memory during reasoning and decision making (Jahn & Braatz, 2014; Renkewitz & Jahn, 2012) by recording eye movements. The basic principle underlying memory indexing is that people look at an emptied spatial location when retrieving information that has been associated with the spatial location during encoding (e.g., Richardson & Spivey, 2000). We use memory indexing to reveal memory dynamics in sequential diagnostic reasoning in order to test process assumptions derived from cognitive models on reasoning and belief updating.

We study sequences of symptoms, for which more than one diagnosis is possible. Reasoners strive for a coherent interpretation of symptoms (Kostopoulou, Russo, Keenan, Delaney, & Douiri, 2012). When two diagnoses compete, coherence can be achieved by biased interpretation of symptoms that increases the belief in one hypothesis while decreasing the belief in alternatives (Holyoak & Simon, 1999; Mehlhorn & Jahn, 2009). Maximizing coherence often favors the initially leading hypothesis. But it can strengthen an alternative when stronger evidence for an alternative hypothesis has accumulated. Then, a \textit{hypothesis change} takes place.

In this study, we test process assumptions of coherence maximization, i.e. biased symptom processing towards the leading hypothesis or hypothesis change, by applying memory indexing and presenting participants with ambiguous symptom sequences, for which coherence maximization over the course of symptom processing can favor one or the other diagnosis. The biases in symptom processing preventing or inducing a hypothesis change should be revealed by participants’ gaze behavior.

\textbf{Method}

The study consisted of a learning phase and a subsequent reasoning phase. During the learning phase, participants acquired the knowledge needed for the reasoning phase. The reasoning task was to determine the most likely cause of a patient’s symptoms. The patients were workers in a chemical plant that produces four chemicals and each worker was affected by exactly one of those chemicals (Mehlhorn, Taatgen, Lebiere, & Krems, 2011).

\textbf{Participants}

Thirty-two students (21 female, $M_{\text{age}} = 22.4$, range: 19-39 years) from Technische Universität Chemnitz participated in the study.

\textbf{Apparatus and Material}

An SMI RED remote eye tracker sampled data of the right eye at 120 Hz in a laboratory setting.

Four chemicals were assigned to screen quadrants (Fig. 1). Each quadrant enclosed three rectangular frames, which contained three symptom classes that the respective chemical could cause. For example, the chemical at the top left caused symptoms from the symptom classes circulation, pain, and skin. One symptom class was unique (pain for the top left chemical, denoted with single small letters, e.g., a) and two symptom classes were shared with other chemicals (denoted with two small letters, e.g., ab).

\textbf{Procedure}

In the learning phase, participants first learned how symptoms were assigned to symptom classes and second how symptom...
classes related to chemicals. Associations between symptom classes and chemicals were established by presenting symptom classes in rectangular frames in the screen quadrants that each represented one chemical (Fig. 1, left side). During reasoning, symptoms were presented auditorily while participants only saw the emptied rectangular frames (Fig. 1, right side). Eye movements were recorded throughout the reasoning phase. The diagnostic decision was collected at the end of the reasoning trial.

Fixation proportions after the first symptom presentation reflected which hypothesis was supported. During subsequent symptom intervals fixation proportions increased towards the most likely hypothesis given the subjective interpretation of symptoms in the symptom sequence. After strong evidence for an alternative hypothesis had accumulated, fixation proportions revealed a hypothesis change for B-responses in sequences starting with an a-symptom and for A-responses in the sequence starting with a B-symptom. Fixation proportions during the response interval reflected which hypothesis was chosen.

Eye movements as revealed by applying memory indexing to the study of sequential diagnostic reasoning of ambiguous symptom sequences reflect the reasoners’ tendency to strive for coherence in interpreting new information. Studying eye movement behavior will inform existing computational models on reasoning and decision making and enhance the understanding even of memory-based reasoning processes.

Acknowledgments
This research was supported by German Research Foundation (DFG) grants KR 1057/17-1 and JA 1761/7-1. The authors would like to thank Ricarda Fröde and Claudia Dietzel for their help in conducting the experiment.

References