Deciphering Dynamic Decision Making Using Cognitive Modeling Including Subjective Assessment

*Ziying Zhang, Nele Russwinkel, Sabine Prezenski**

More breakthroughs in computer science, psychology, and cognitive science allow us to obtain new insights for developing artificial intelligence (AI) that understand and predict the behavior and decision-making process of humans. In real changing environments, decision-making consists of series of decisions, and these depend on the corresponding feedback. Cognitive modeling provides a method to understand and explain them in general. This work is a demonstration of how cognitive modeling allows to flexible simulate decision-making in dynamic environments for different individuals as well.

This work builds upon previous work on cognitive modeling of a dynamic decision-making task in category learning [1]. We conducted an empirical study of an improved version of this task. This task requires participants to categorize tones (consisting of different acoustic features) and find out a target category, by applying acoustic strategies and learning from feedback of each trial's judgment. In the new version, two swaps on the correct key representing target tones were set. Furthermore, subjective confidence assessment and retrospective reports were added to explore participants´ thought-processes. The data of 50 subjects was collected. A first model based on the cognitive architecture ACT-R was developed, following the previous approach [1]. It begins by trying out one-feature strategies (e.g. frequency) and then switching to two-feature strategies (e.g. frequency + volume) as a result of negative feedback. However, after analysing each individual's performance, a large variance among individuals was found. The first model which only considers acoustic feature strategies could not simulate individuals who considered the possibility of the changing the correct key in each trial. Thus, to account for actual flexibility in decision-making, an upgraded second model was developed. This second model considers the actual (motor) operation in the task - pressing the correct key for target tones. It contains two independent strategy learning factors: the acoustic strategy derived from the first model and the new knowledge about key assignment. To control this knowledge of keys, a metacognitive count threshold mechanism of continuous negative feedback is added. The second model provides a better fit to the data of those participants who stated that they prefer to consider multi-factors in the task, and a similar fit for the average empirical learning curves than the first model. What our study proves is that cognitive modeling approaches with ACT-R can be extended to account for different individual cases. The capacity for predicting decision-making in complex tasks and furthermore being adaptable to individual differences in such tasks is a great potential for applying such ACT-R modeling approaches to develop better AIs.

[1] Prezenski, S., Brechmann, A., Wolff, S., & Russwinkel, N. (2017). A cognitive modeling approach to strategy formation in dynamic decision making. *Frontiers in psychology,* 8, 1335.

*corresponding author (email: `sabine.prezenski@tu-berlin.de`)

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