Task modelling and model validation for car driving

Task analysis is a powerful tool to model human behavior within sociotechnical systems. However, the validation beyond expert judgement has received inadequate attention. The problem is exacerbated in dynamic environments where discrete task execution stages are difficult to model. We argue that model validation should follow an iterative approach using the TASC conceptual framework presented here. Building on Gray and Boehm-Davis' (2000) notion of interactive behavior, TASC splits behavior into the Task under consideration, Actions taken, the Situation, and the human embodied Cognition. The approach consists of a) conducting the task analysis to define a task model, b) data collection, and c) validating the task model on the levels of action, situation, and cognition. This framework is demonstrated using a lightweight task analysis of the driving task. A Cognitive Work Analysis (CWA) of the driving task was conducted, yielding five top-level goals. Subsequently, data were gathered in a driving simulator. Twenty-one participants drove on a two-lane motorway in two scenarios in random order. The "controlled" scenario consisted of vehicles showing very predictable behavior; the "realistic" scenario had medium-dense traffic behaving similarly to everyday traffic. The participants were instructed to drive according to traffic rules. Eye-tracking data were recorded. Nine participants drove the two scenarios again while being instructed to think aloud focusing on perceptions and goals. Based on the data, we produced separate graphical representations for the TASC levels of action, situation, and cognition representing the time course of the drive for each subject. The cognition-level was split into perception (eye tracking) and goals (thinking aloud). Finally, on each level, each CWA goal was operationalized and statistically evaluated using linear mixed models. Behavior on right lane differed markedly from behavior on left lane in line with the CWA goals. Goals appeared clearly in driving actions, gaze behavior, and thinking aloud utterances. Visual behavior shows a distinctive pattern depending on situational requirements in different phazes of the drive. The TASC-framework proved very useful to validate the CWA task analysis. The idea of task analysis has limitations in modelling driving because of a strong reliance on discrete states. Yet an important property of the driving task is its execution in the continuous world of time, space, and energy. Goals act frequently not as states to be achieved but as constraints on possible actions and can be quickly altered depending on the dynamic situation. More effort should be directed towards validation of task models. We recommend making operationalization of task models standard practice when conducting task analysis to help planning of evaluation studies and assessment of generalizability of results beyond the task environment studied. To gain a better understanding of the cognition of task execution, more research into setting of multiple goals, action selection, and situation representation in dynamic environments is highly desirable.

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