

The Interplay Between Driver Dynamic Trust and Their Self-Confidence in Monitoring Automation

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Abstract

As vehicles become increasingly automated, understanding how drivers trust these systems is crucial for both safety and effective use. Our research explores how drivers' moment-to-moment trust in vehicle automation relates to their self-confidence in detecting system errors. Using simulated driving scenarios, we observed how drivers monitored automated systems under varying traffic conditions and automation performance. Our preliminary findings highlight that while higher traffic demands and automation errors negatively impact drivers' ability to detect system errors, their trust aligns more closely with their self-confidence in judging automation performance than with their perceptual sensitivity or decision criteria. This study provides insights into the psychological processes influencing driver interactions with automation and emphasizes the unique role of self-confidence in effective monitoring. Understanding these dynamics can support the design of automated systems that promote safer driving behaviors.

Keywords

attention, automation, transportation and mobility, trust, confidence

Introduction

With increasing levels of vehicle automation, understanding driver trust and reliance on these systems is essential for both safety and optimal system utilization (Lee & See, 2004). Distrust may lead to underuse, whereas overtrust can result in safety-critical risks (Parasuraman & Riley, 1997; Walker et al., 2023). However, trust is not static; it evolves in real-time as drivers interact with automation. This study investigates how moment-to-moment (dynamic) trust influences driver monitoring behavior through three potential mechanisms. Specifically, we examine whether fluctuations in trust affect decision-making criteria, sensitivity to automation errors, and participants' confidence in their judgments about automation performance. Importantly, we emphasize the need to examine this specific type of confidence, which we argue is distinct from the traditional definition of confidence in automation or drivers' ability to perform driving tasks.

Background

Prior research indicates that driver trust correlates with attention allocation during vehicle automation (Hergeth et al., 2016; Walker et al., 2019). However, the mechanisms remain unclear. We propose three potential pathways through which

trust might influence monitoring performance. The first pathway involves *Decision Criterion Shifts*. Higher trust might lead drivers to adopt a more lenient criterion when judging automation performance, accepting system outputs with less scrutiny. The second pathway relates to *Sensitivity to Signals* in the presence of noise. This may be through emotional factors, such as anxiety, which may interact with trust to affect perceptual sensitivity indirectly (Kraus et al., 2019). The third pathway concerns *Self-confidence in Monitoring Success*. Trust influences a driver's focus on monitoring automation performance, especially when engaging in non-driving-related activities. Confidence is crucial in this context, as drivers who lack confidence in whether they are effectively detecting any anomalies are likely to continue monitoring until reaching a threshold level of certainty about their monitoring effectiveness. This framework guided our experimental design by highlighting the need to measure not

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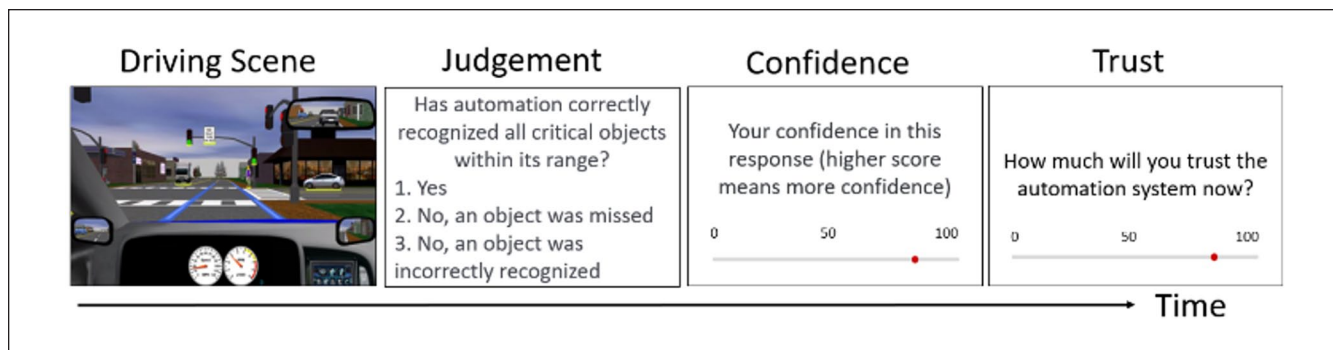


Figure 1. An example trial of the HAC-DAT task.

only accuracy and sensitivity but also confidence ratings as an indirect measure of trust.

It is important to note that driver self-confidence in monitoring success differs from the traditionally defined confidence in automation or confidence in the driver's own capability to complete the driving task (Miele et al., 2021). Current vehicle automation technology is not designed for the driver and the automation to each take responsibility for distinct subtasks (i.e., collaboration); instead, the driver oversees automation performance and takes control when needed (i.e., supervision). This essential difference in the driver's role highlights the importance of examining driver confidence in self-assessed certainty about the correctness of their moment-to-moment judgment concerning automation performance.

Approach

We conducted a preliminary online study with 20 undergraduates (mean age = 20 years, 60% women) from the Psychology participant pool at North Carolina State University. Participants performed the Human Automation Collaboration-Drive Aware Task (HAC-DAT), an adapted Drive Aware Task (Feng et al., 2015, 2018) that incorporates augmented reality cues indicating which critical objects (e.g., lanes, traffic lights, signs, pedestrians, and vehicles) are recognized by the automation (Figure 1). The task features a 2 (perceptual load: high, low) \times 3 (automation correctness: correct, miss, false alarm) within-subject design.

The experiment featured driving scenes across urban, residential, highway, and rural environments, with the perceptual load being either low or high. In the high perceptual load condition, scenes included more than five critical objects (e.g., vehicles, pedestrians, traffic signs), while the low load condition featured fewer than five. Participants completed 50 trials, 32% (16 trials) of which involved an automation error. To ensure consistent measurement of dynamic trust and confidence, a predefined pseudo-randomized order of trials was applied to all participants. In each trial, after viewing a driving scene for 5 s, participants judged whether the automation correctly recognized all critical

objects, missed an object, or falsely identified an object. They then rated their confidence in their own judgment of monitoring success using a 0 to 100 slider. If they reported a miss or false recognition, they had to describe the object to reduce guessing in the task. At the end of each trial, participants are asked to report their moment-to-moment trust in the automation system they are monitoring using a 0 to 100 slider. This design allowed us to compute HAC-DAT task accuracy, perceptual sensitivity, and decision criteria using signal detection analysis, and self-confidence. Participants also reported demographic information, driving exposure, and experience with vehicle automation.

Findings

About 2×3 within-subject ANOVAs were performed with load (high or low) and trial type (correct, miss, false alarm) as factors, examining outcome variables including HAC-DAT task accuracy, decision criteria, sensitivity, and self-confidence. Correlations were conducted between trust and other variables, including decision criteria, sensitivity, and confidence, using directional tests.

Overall, there were significant effects of load and trial type and their interaction on accuracy but not on confidence. Under a higher traffic load and when automated made an error, participants' judgments were less accurate. Trust correlated significantly with confidence but not accuracy. Below are the more detailed results from each outcome measure (Figure 2).

Accuracy

Accuracy was lower with a higher task load and in trials when automation had an error. There was an interaction between load and trial type, with the load affecting accuracy more in automation-incorrect trials.

Sensitivity and decision criteria

Signal detection analysis revealed that participants became less sensitive and shifted their decision criteria to be less

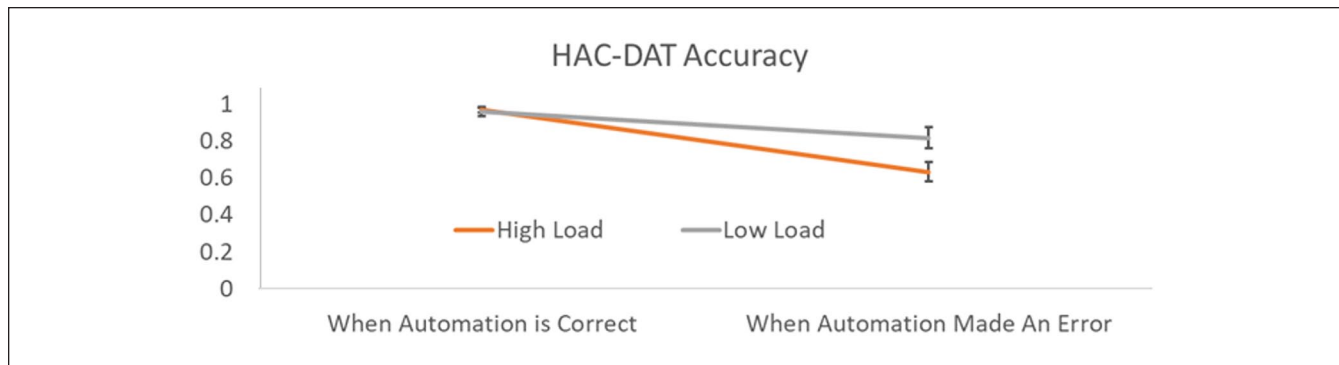


Figure 2. HAC-DAT accuracy by perceptual load and automation correctness. Error bars represent ± 1 standard error of the mean.

conservative in the high load condition. That means they were less perceptually capable and more likely to believe that automation made an error in high traffic load.

Confidence

Confidence did not change based on task load or trial type.

Dynamic Trust

Participants' trust in vehicle automation showed individual variability, but did not correlate with participants' overall task accuracy ($r = .14$), sensitivity ($r = .08$), or decision criteria ($r = -.19$). However, trust correlated significantly with confidence in their judgment ($r = .39$).

Conclusion

This study examined three potential mechanisms by which dynamic trust may influence driver attention when monitoring vehicle automation. The findings indicate that dynamic trust in automation co-varies with driver self-confidence in their monitoring success but does not correlate with decision criteria or sensitivity when detecting automation errors. While these results are preliminary with a small sample size, they suggest that self-confidence in monitoring success is the primary mechanism, aligning with prior research (Hergeth et al., 2016; Walker et al., 2019).

The study also highlights the uniqueness of vehicle automation monitoring tasks because the current technology places the driver in a supervisory role rather than a collaborator role. The lack of correlation between sensitivity or decision criteria and trust may seem surprising but may be explained by prior findings that stronger accuracy-confidence links in memory tasks than in perceptual tasks (Jin et al., 2022). Given that automation was mostly correct in this experiment and in real-life applications, confidence likely reflects the degree of assurance in automation correctness. However, these findings are highly preliminary due to the small sample size ($n = 20$) used for

correlational analyses, so they should be interpreted with caution.

Future research should include a larger sample size, explore varying levels of automation reliability, how confidence evolves with experience, and leverage more advanced statistical methods such as multi-level modeling to examine the effects of various within- and between-subject factors. The current HAC-DAT task provides a valuable tool for efficiently assessing human performance in monitoring automation when drivers assume a supervisory role.

Declaration of Conflicting Interests

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