

Balancing Human and System Autonomy: Detecting and Preventing Overdependence In Decision-Making

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As artificial intelligence (AI) becomes increasingly ingrained in everyday decision-making, concerns have emerged regarding overdependence and how it might weaken human autonomy. This issue is crucial in human-autonomy teaming research. Previous studies identified cognitive load as a core mechanism driving autonomy depletion as users became overwhelmed by task demands and progressively defaulted to AI-generated responses which resulted in eroding their capacity for independent judgement (Margondai & Mouloua, 2026; Margondai, Willox, & Mouloua, 2025). A systematic review of conversational AI systems confirms that this defaulting pattern constitutes real overdependence. Users accept the AI-generated responses without critical evaluation thus resulting in measurable impairment of independent decision-making and analytical reasoning (Gao et al., 2024). This study looks deeper into this issue and continues the framework presented in prior research. It introduces rumination computationally as a moderating variable and incorporates this concept into an agent-based simulation (ABS). The study presents a simulation framework using autonomous agents that are defined by two psychological dimensions. The first is the Ruminative Response Scale (RRS-10) to predict ruminative tendencies. The second dimension is baseline autonomy confidence that is modulated by neuroticism. This trait is a part of the Big Five Personality Inventory and is most consistently linked to ruminative cognition (Vasupanrajit et al., 2023). Agents work in task environments that

vary in cognitive load, which acts as a stressor that triggers AI assistance-seeking behavior. Each AI assisted event produces two effects: partial task resolution and reduction of the agent's autonomy. Furthermore, agents who show higher levels of rumination experience amplified autonomy depletion with each AI assisted event. This allows for the creation of a self-reinforcing feedback loop where self-doubt leads to dependence on AI, this dependence reduces confidence, and reduced confidence feeds into more ruminative thinking (Hu, Mao, & Kim, 2023). Decision making scenarios including high-stakes writing, operational planning, and time-pressured judgement tasks, serve as environmental triggers in the simulation that elicit different behavioral responses based on the agent's profile.

The simulation conducted aims to find and identify the conditions that lead to this critical depletion within human autonomy and when intervention is required. It also identifies agent profiles most vulnerable and at risk of overdependence. The measurements include the trajectory of autonomy over time, assistance-seeking distributions by rumination profile, and cognitive load states beyond which autonomous recovery becomes unlikely without external support. This work provides three contributions to the modeling and simulation community. First, it provides a formal computational implementation of the autonomy depletion mechanism proposed by Margondai and Mouloua (2026), enabling formal hypothesis formulation prior to empirical testing. Second, it captures the psychological constructs like rumination, cognitive load, and autonomy confidence and how they can be operationalized as state-dependent agent parameters in human autonomy teaming simulations. Third, it develops a simulation testbed for the evaluation of adaptive AI system designs that modulate autonomy support based on detected user state thus preserving rather than displacing human agency. These findings have direct

applicability to defense operations, healthcare decision support, and any area where AI-assisted decision-making has critical consequences.

References

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