When Should Feedback Be Given for Autonomous System Updates? An Examination Across Two Update Patterns

Objectives (up to 500 words):

Describe the problem or need, relevant background, specific goals, and aims driving the research or applied work, providing a clear roadmap for investigating, analyzing, and ultimately achieving the desired outcomes. Include key research questions, if applicable.

System update is a critical mechanism to enhance products in use. It is widely applied across various domains, from mobile applications to autonomous systems such as robots and autonomous vehicles. Specifically, for autonomous systems, updates are key to continuous evolution and enhanced performance. Despite the primary goal of updates being to enhance product performance—aiming for fewer bugs, faster operation, and new features—the user response is not universally positive.

Therefore, understanding how to enhance the effectiveness of updates has become a critical topic in recent research. While previous studies have focused on aspects such as update content, frequency, and users' prior experiences, they often neglect the broader impact of updates on user perceptions, particularly the role of post-update feedback. Traditional feedback mechanisms, often consisting of only simple descriptions or basic notifications of successful installations, do not effectively communicate the benefits of updates to users. This oversight suggests a significant potential for refining user perceptions of updates by rethinking and improving how feedback is provided.

Notably, only one study has pinpointed visualization method, specifically line chart, as the most effective feedback method for positively influencing user's perception of update degree. However, the aforementioned study primarily focused on single-trend improvements, neglecting the diverse and realistic scenarios of product updates. In actuality, the effects of updates on product performance are not always linear and can lead to temporary performance setbacks. For example, major companies, including Apple, Microsoft, and Tesla, have encountered scenarios where updates inadvertently led to diminished performance. This inconsistency introduces a unique challenge: assessing whether the proven effectiveness of feedback method, such as line chart, in improving user perception of update can be maintained across various update patterns, including those that may temporarily degrade product performance. Moreover, these feedback methods might inadvertently increase users' awareness of unfavorable updates. Consequently, this could diminish their overall perception of the update degree and negatively impact their interaction with and purchasing choices for the product.

This study aims to delve into the effect of updates feedback method on user perception in different update patterns, such as steady performance improvements, sharp fluctuations (see Supporting Information, Figure 1). The study seeks to provide a nuanced understanding of how feedback can be strategically utilized to manage user expectations and satisfaction across different update patterns. By developing guidelines for employing feedback in updates, this research strives to optimize user perception and satisfaction, regardless of the update's immediate impact on system performance.

Approach (up to 250 words):

State the methods, processes, practices, or methodological framework employed to address the objectives.

This study adopted a within-subject design, employing a 2 (feedback method: no feedback/visualization feedback) × 2 (update pattern: steady improvement /sharp fluctuations) experimental scheme to explore the impact of different feedback methods and update patterns on users' perceptions of the vehicle update process. A total of 61 participants were recruited online and invited to the offline laboratory, comprising 30 males and 31 females, with an average age of 23.01 years (SD = 2.65) and an average driving experience of 2.58 years (SD = 1.76).

Before the experiment commenced, participants signed informed consent forms and were introduced to the experimental program. They then read through the instructions, which informed them that they would view a series of videos depicting the update process of a car's automatic parking system (To ensure consistency in the first and final update level across different update patterns, these videos have been previously evaluated by another group of participants for performance through a pilot study). Participants were instructed to watch these videos attentively and evaluate the updating process using specific scales, including perception of the update degree, recommendation intention, user satisfaction, and purchase intention (see Supporting Information, Figure 2). After completing all evaluations, participants were asked to fill out demographic variables, which included their driving experience, experience with autonomous driving, and driving frequency. Finally, participants were debriefed, thanked, and compensated for their time. The entire experiment lasted about 15 minutes. They were compensated 20 yuan (approximately 3 dollar) for their participation.

Findings (up to 250 words):

Summarize the main findings, novel outcomes or insights, patterns, or correlations relevant to the research questions (if applicable). Briefly describe how these findings contribute to the existing body of knowledge and practices in the field of human factors and ergonomics.

This study utilized a two-way ANOVA to explore the impact of feedback methods and update patterns on user perceptions (see Supporting Information, Figure 3 and 4). Feedback significantly enhanced perception of update degree during steady improvements, demonstrated by the interaction effect ($F = 1.870$, $p = .156$, $\eta^2 = .010$). In steady upgrades, feedback led to higher scores compared to no feedback, while in sharp fluctuations, feedback did not differentiate the scores.

The interaction effect was consistent for recommendation intention scores ($F = 5.531$, $p = .004$, $\eta^2 = .030$), with feedback improving scores in steady upgrades but having no significant impact in sharp fluctuations.

Similarly, user satisfaction and purchase intention scores were influenced by the interaction between update patterns and feedback (user satisfaction: $F = 6.301$, $p = .002$, $\eta^2 = .034$; purchase intention: $F = 6.204$, $p = .002$, $\eta^2 = .033$). Feedback was beneficial in steady improvements, while in sharp fluctuations, it did even decreased scores.

These findings advance the field of human factors and ergonomics by showcasing the conditional role of feedback in molding user experiences with updates. It suggests that customizing feedback according to the specific update pattern is key to optimizing user experiences, thereby facilitating better technological adoption, and enhancing overall user satisfaction. This underscores the intricate relationship between

feedback strategies, user perceptions, behavior in the context of autonomous system updates.

Takeaways (up to 250 words):

Describe the essential lessons and implications drawn from the findings. Offer practical insights or theoretical contributions that resonate beyond the immediate context of the study or applied work. By presenting actionable recommendations and thought-provoking insights, the takeaways underscore the impact and relevance of the work within the broader academic and practical landscape.

First, our study underscores the importance of customizing feedback to the specific nature of technology updates, a strategy that significantly enhances user satisfaction and perception. Particularly in scenarios of steady improvement, feedback that highlights the successes of an update can reinforce positive user experiences, proving the effectiveness of this approach.

Second, the landscape changes with volatile update patterns, where sharp fluctuations present a unique challenge. In these situations, feedback requires a more nuanced approach, possibly involving managed expectations or more detailed explanations, to mitigate the risk of lowering satisfaction and purchase intentions. This complexity highlights the need for developers and designers to carefully navigate the intricacies of volatile updates.

Furthermore, the findings reveal that enhancing user experiences with technology updates involves more than just improving the updates themselves. Effective communication and strategic feedback play a crucial role in shaping user perceptions, marking a shift towards a holistic approach in update deployment. This insight is critical for practitioners, emphasizing the importance of understanding the diverse impacts of feedback across different update patterns to develop more effective feedback mechanisms.

In summary, this research lays a solid foundation for future exploration into feedback strategies in autonomous system updates, offering actionable recommendations for practitioners. It calls for a deeper investigation into how these strategies can be refined to align with evolving user expectations, thereby enhancing overall satisfaction with autonomous systems. This not only provides a roadmap for optimizing feedback strategies but also highlights the broader implications and potential for continued research in this area.

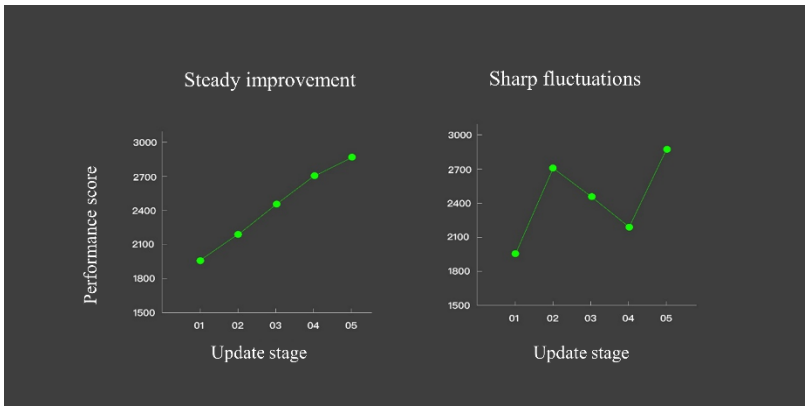

Figure 1：Changes in system performance across two update patterns.

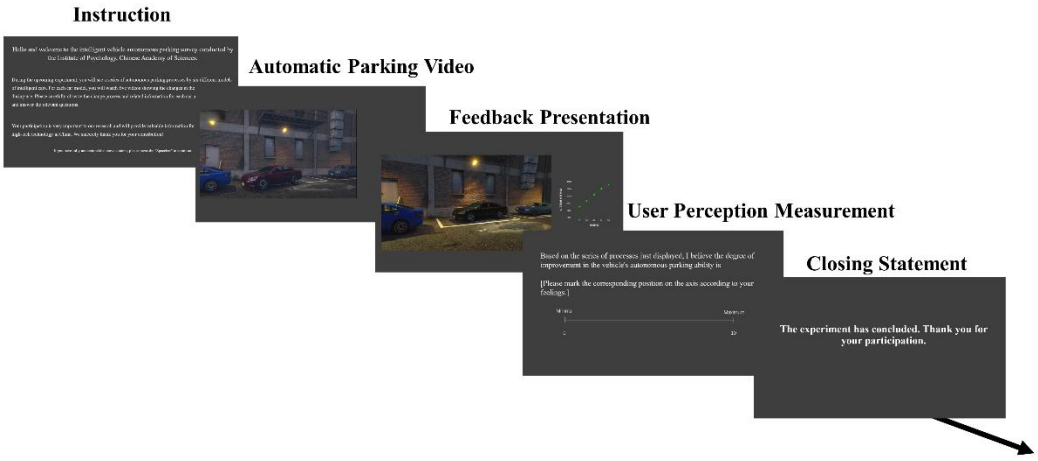

Figure 2：Flowchart of a single trial within the experiment (visualization feedback and steady improvement condition).

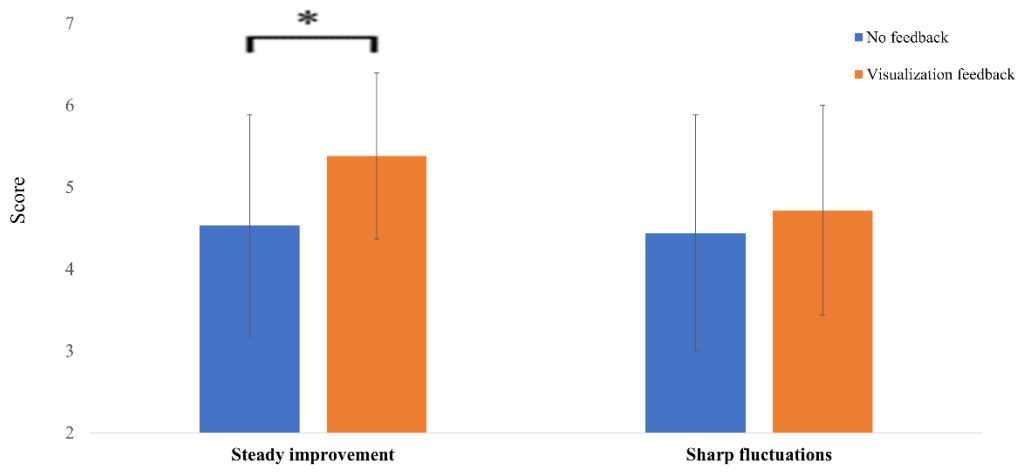

Figure 3：Perceptions of update degree across two update patterns.

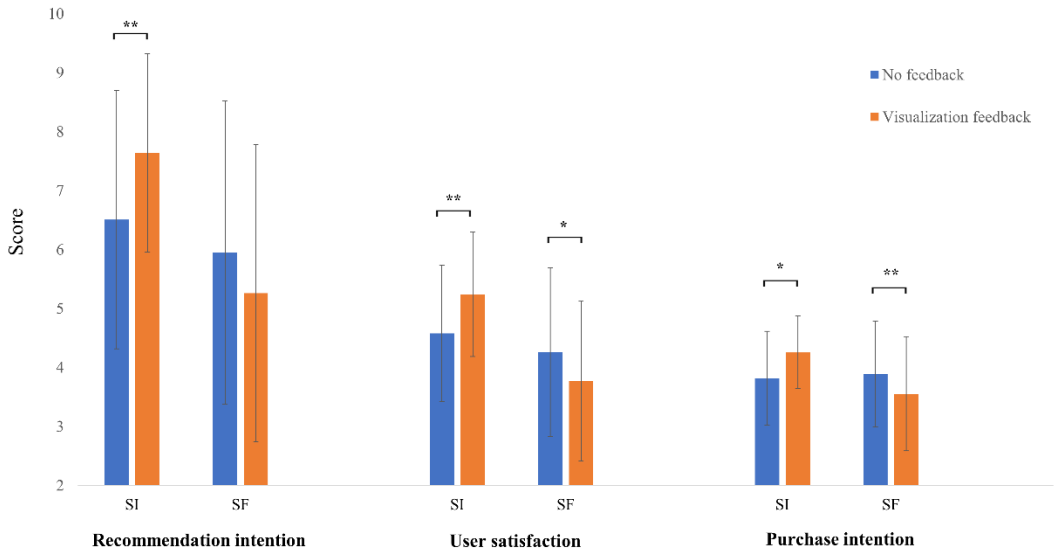

Figure 4：User recommendation intention, satisfaction, and purchase intention scores across two update patterns (SI: steady improvement, SF: sharp fluctuations).