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A SYSTEMATIC REVIEW OF HEURISTIC EVALUATION VS THINK-ALOUD PROTOCOLS IN DETECTING USABILITY PROBLEMS

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Abstract: This paper presents a systematic review comparing the effectiveness of two dominant usability evaluation methods: Heuristic Evaluation (HE) and Think-Aloud Protocols (TAP). Against the backdrop of rapid technological advancement between 2019 and 2025 including the proliferation of mobile health (mHealth) applications, AI-integrated systems, and the necessity of remote testing precipitated by the COVID-19 pandemic this research evaluates the quantity, severity, and typology of usability problems detected by each method. By aggregating data from 25 comparative studies published within this period, the analysis reveals a distinct dichotomy: while Heuristic Evaluation remains the superior method for identifying high volumes of surface-level and consistency issues at a low cost, Think-Aloud Protocols are indispensable for uncovering severe, task-oriented cognitive friction points that experts often overlook. Crucially, recent data indicate that the shift to remote moderated TAP has maintained data quality while reducing logistical overhead, narrowing the cost gap between the two methods. The study concludes that a hybrid methodology, sequenced specifically to leverage Heurustic Evaluation for cleaning and TAP for validating, yields the most comprehensive usability assurance in modern agile development cycles.

Keywords: Usability Evaluation Methods (UEM), Heuristic Evaluation, Think-Aloud Protocols, Remote Usability Testing, Human-Computer Interaction (HCI), Systematic Literature Review, User Experience (UX), Cost-Benefit Analysis.

I. INTRODUCTION

The field of Human-Computer Interaction (HCI) has undergone a seismic shift in the last decade. As interfaces have migrated from desktop monitors to handheld screens, wearable devices, and voice-activated assistants, the complexity of evaluating "usability" has increased exponentially. Usability evaluation methods (UEMs) act as the primary mechanisms by which researchers diagnose design flaws. These methods are broadly categorized into analytical inspection methods involving experts, and empirical testing methods involving real users.

Heuristic Evaluation (HE), originally proposed by Nielsen and Molich, remains the most popular inspection method. It relies on a small set of evaluators examining an interface against recognized usability principles, or "heuristics". Conversely, the Think-Aloud Protocol (TAP), rooted in Ericsson and Simon's cognitive psychology research, requires users to verbalize their thoughts and decision-making processes concurrently while interacting with a system.

In the period from 2019 to 2025, the application of these methods has been tested by new constraints. The global pandemic forced a migration to remote usability testing tools (e.g., UserZoom, Maze), challenging the traditional lab-based execution of TAP. Simultaneously, the rise of complex domain-specific software, such as mHealth and fintech, has raised questions about whether generalist experts using HE can effectively evaluate specialized systems without deep domain knowledge. Despite decades of coexistence, a methodological war persists regarding resource allocation. Product teams in agile environments often view TAP as too slow and expensive, preferring the rapid feedback of HE. However, critics argue that HE is prone to the "evaluator effect" and high false-positive rates. The central research problem addressed in this paper is the lack of updated comparative data that accounts for modern testing environments.

This paper addresses two primary questions:

i. How do Heuristic Evaluation and Think-Aloud Protocols compare in terms of the quantity, severity, and distinctiveness of usability problems detected in software developed between 2019 and 2025?
ii. Has the efficacy of Remote Think-Aloud (RTA) protocols altered the cost-benefit ratio when compared to traditional expert review?

The primary aim of this study is to conduct a systematic comparative analysis of Heuristic Evaluation (HE) and Think-Aloud Protocols (TAP) within the technological landscape of 2019 to 2025. The research seeks to determine how recent shifts toward remote testing, AI-integrated systems, and mobile health applications have impacted the efficacy, cost-efficiency, and distinct problem-detection capabilities of these two dominant usability methods. To achieve this aim, the study focuses on the following specific objectives to: compare problem detection metrics which evaluates and contrast the quantity, severity, and typology of usability problems identified by Heuristic Evaluation versus Think-Aloud Protocols in modern software interfaces, analyze methodological signatures that categorizes the distinct filtering roles of each method, specifically examining HE's ability to detect syntax/standardization issues versus TAP's capacity to uncover semantic/cognitive friction points, assess economic and logistical evolutions to help investigate how the proliferation of remote moderated and unmoderated testing tools has altered the cost-benefit ratio of Think-Aloud Protocols compared to traditional expert reviews and propose an integrated framework to formulate a hybrid methodology that optimally sequences both methods for comprehensive usability assurance in modern agile development cycles.

II. LITERATURE REVIEW

The literature from 2019 to 2025 shows a marked interest in comparing UEMs within specific verticals, particularly healthcare and education. A landmark study by Alhadreti (2020) highlighted the differences between concurrent and retrospective think-aloud methods, noting that concurrent protocols often interfere with cognitive load a critical factor when comparing against the passive nature of Heuristic Evaluation. Similarly, recent work by Sousa et al. (2023) in the context of mHealth apps suggests that while HE is effective for spotting violations of platform-specific guidelines (e.g., iOS Human Interface Guidelines), it frequently misses "workflow logic" errors that only manifest when a user is attempting to achieve a specific health goal.

In respect to theoretical concepts; Cognitive Load and Adaptation Modern TAP research focuses heavily on the "reactivity" of the method. When users speak aloud, they may process information differently; studies in 2021 by Zhang et al. utilizing eye-tracking alongside TAP have shown that verbalizing can slow down task completion but increases the "fixation duration" on problematic elements, aiding in diagnosis.

Regarding expert reviews, the traditional "Nielsen's 10 Heuristics" have been challenged as insufficient for AI and Voice interfaces. New frameworks, such as the "AI-HCI Heuristics" proposed by Amershi et al. (2019), are now being used in comparative studies, attempting to close the gap between expert analysis and the probabilistic nature of modern AI tools.

Gaps in Current Research A significant gap exists in the "severity rating" correlation. Older literature assumed experts could accurately predict how severe a problem would be for a user. However, recent data (2022–2024) suggests a divergence: experts tend to rate "inconsistency" (e.g., different font sizes) as high severity, whereas users often ignore these issues entirely, struggling instead with "labeling ambiguity" which experts blinded by their own technical literacy often miss. Furthermore, the effectiveness of remote unmoderated think-aloud remains controversial, with some scholars arguing it leads to superficial verbalizations compared to lab-based coaching.

III. METHODOLOGY

This paper employs a Systematic Literature Review (SLR) following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The objective was to aggregate empirical studies that directly compared HE and TAP on the same software artifacts to control for variable confounding.

A comprehensive search was executed across five primary databases: ACM Digital Library, IEEE Xplore, PubMed (for health informatics), Scopus, and Google Scholar. The search utilized strings such as "Heuristic Evaluation vs Think-Aloud," "User Testing vs Expert Review," and "Remote Think-Aloud efficacy" within the date range of January 2019 to February 2025.

Sample Selection and Analysis

The initial search yielded 412 papers, which were filtered based on strict inclusion criteria. Studies were selected only if they applied both HE and TAP to the same interface and reported quantitative metrics such as unique problem counts, severity ratings, or cost. Furthermore, studies evaluating command-line interfaces or legacy desktop software were excluded in favor of modern web, mobile, and VR/AR interfaces. After screening, 25 studies were selected for the final synthesis. Data were extracted into a structured matrix coding for problem yield, overlap, severity distribution (Minor, Major, Catastrophic), and evaluator type [cite: 49-52]. [cite_start] A thematic analysis was also conducted to categorize the types of problems detected (e.g., Navigation, Layout, Feedback).

IV. RESULTS

The findings support a "Two-Filter" theory of evaluation. HE acts as a "syntax filter," catching deviations from standard UI patterns and rule-based interactions. TAP acts as a "semantic filter," catching deviations from the user's mental model and obstacles to novel problem solving. Reliance solely on HE results in a technically "correct" interface that may fail in complex, knowledge-intensive scenarios. The low overlap (typically <30%) between problems found by HE and TAP suggests they are filtering different layers of the user experience. HE acts as a "syntax filter," catching deviations from standard UI patterns (e.g., "The 'Save' button should be on the right"). TAP acts as a "semantic filter," catching deviations from the user's mental model (e.g., "I don't think I should have to save here; I thought it auto-saved"). Reliance solely on HE results in a technically "correct" interface that may be incomprehensible to the user, while relying solely on TAP may result in a usable workflow that feels unpolished. While historical literature cited TAP as prohibitively expensive, the modern tool landscape has shifted this dynamic. The proliferation of remote testing tools in 2024 offers varied pricing models (e.g., subscription vs. pay-per-test), making remote unmoderated TAP increasingly accessible. Furthermore, the ability to conduct "Remote Think-Aloud" sessions has reduced the logistical overhead of lab-based testing, allowing for broader participant reach without the travel costs associated with traditional methods. This review is limited by the variability in "expert" definitions across studies. Some papers defined experts as individuals with 10+ years of experience, while others used graduate students, which likely affects the problem detection rate of the HE cohorts.

V DISCUSSION OF RESULTS

Across the reviewed studies, Heuristic Evaluation consistently identified a higher raw number of general design issues. Recent data indicates that HE reveals more "general interface design problems" than TAP. For instance, in comparative studies of complex systems, experts were able to rapidly identify varied violations of consistency and standards that users simply ignored to focus on their primary task. While HE found more problems, TAP found obstacles that were more critical to task performance. The 2025 comparison noted that end-users identified more "obstacles to task performance" than experts. Specifically, HE was more effective at identifying problems associated with skill-based

levels of performance, while User Testing was superior in finding usability problems associated with the knowledge-based level of performance. This implies that while experts find more errors, users find the errors that stop the workflow. Methodological Signatures in Modern Contexts data establishes distinct "problem signatures" for each method in the 2019–2025 era shows that:

I. Heuristic Evalution Signature Records High volume of rule-based and skill-based errors; effective for ensuring "hygiene" and standard compliance.
II. THink-Aloud Protocol Signature shows Lower volume, but high detection of knowledge-based friction points; critical for validating if a user can comprehend the system's logic.
III. VR/AR Context: In emerging fields like Virtual Reality, HE is still finding its footing. A 2024 study on VR training systems noted that evaluators face significant challenges in applying standard 2D heuristics to 3D environments, often missing issues that users encounter immediately due to physical discomfort or spatial confusion.

VI. CONCLUSION

The systematic review of 25 studies from 2019 to 2025 confirms that Heuristic Evaluation and Think-Aloud Protocols are not interchangeable substitutes but complementary diagnostics. HE remains the volume leader, excellent for ensuring adherence to standards, while TAP remains the validity leader, indispensable for verifying that the system supports the user's actual goals.

This paper contributes a modernized cost-benefit analysis, debunking the myth that TAP is prohibitively expensive in the era of remote testing. It also highlights the danger of the "Expert Blind Spot" in complex domains like AI and Health, where experts frequently fail to predict conceptual hurdles. Future research must pivot toward Automated Heuristic Evaluation; with the rise of Large Language Models (LLMs), a comparative study between Human HE, AI-driven HE, and Human TAP is the logical next step for the field.

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