

Experience Optimization of Smart Kitchen Service Systems for Older Adults

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Abstract: As intelligent technologies increasingly penetrate domestic environments, the kitchen is undergoing a transformation from a functional space to a smart service system. This study focuses on older adults and investigates key mechanisms for optimizing their user experience in smart kitchens. Based on an integrated framework of service design and experience design, the research employs user journey analysis, service blueprinting, and prototype testing to identify behavioral pain points and emotional needs in the stages of meal preparation, cooking, and cleaning. Results indicate that multimodal interactions and affective feedback significantly enhance users' sense of trust, safety, and control. The study proposes an Affective-Driven Optimization Framework for Smart Kitchen Service Systems, offering both theoretical grounding and practical guidance for age-friendly and emotion-responsive smart home design.

Keywords: Smart Kitchen; Service Design; Experience Optimization; Age-Friendly Design; Affective Interaction

1. Introduction

Human living spaces in the 21st century are shifting from functional rationality to experiential rationality. As the emotional and cultural core of the home, the kitchen carries not only the physical function of food preparation but also intergenerational communication and cultural continuity. With the rise of smart-home technologies, the kitchen has gradually acquired automation and intelligent features: voice control, smart cooktops, nutritional recognition, and AI-based recipe recommendation systems are reshaping everyday cooking experiences. However, current smart-kitchen designs primarily serve the convenience and efficiency needs of younger users, while overlooking older adults' cognitive differences, emotional expectations, and safety concerns.

When facing multimodal interaction interfaces, older users often encounter disorientation, delayed feedback, and speech-recognition errors. Such technical "friction" translates into anxiety, frustration, and dependency at the experiential level, diminishing their self-efficacy and confidence in daily life. This reveals a fundamental paradox of current smart-kitchen design: as technology becomes more intelligent, human experience is not necessarily becoming wiser.

Accordingly, this study argues that smart-kitchen design for older adults should shift from a function-oriented to an experience-oriented approach, and from control logic to service logic. Grounded in service design methodology and guided by experience optimization, the study constructs user journeys and interaction models to reveal how emotional factors mediate older adults' experience with smart kitchens. Combining qualitative and quantitative methods, it seeks to address three key questions:

- (1) What are the primary experiential pain points and psychological characteristics of older users

in smart kitchens?

(2) How can multimodal interaction improve emotional security and operational trust through service-level design?

(3) How can smart kitchens evolve from technological empowerment to emotional symbiosis?

The goal is to propose an integrated, affective-driven, and service-system-based framework for age-friendly smart-kitchen design. Beyond improving daily usability, this research advocates for a more humanistic design ethic in the intelligent era—to let technology understand people, rather than forcing people to adapt to technology.

2. Literature Review and Theoretical Foundation

As a vital component of smart-home systems, the Smart Kitchen has evolved from the early Internet-of-Things integration phase to the current AI-driven phase. Early research mainly focused on connectivity and automation—such as temperature monitoring, energy management, food identification, and cooking-process control—emphasizing convenience and efficiency [1]. With the emergence of artificial intelligence and big-data analytics, attention has shifted from functional implementation to service experience. Examples include AI recipe systems that generate personalized menus based on health data and dietary preferences, and intelligent voice assistants that provide cooking guidance and emotional companionship. This phase foregrounds contextualization and emotionalization of human-machine interaction [2]. Yet most studies still center on younger users, neglecting the cognitive, perceptual, and trust differences of older adults. For them, the “efficiency” of technology often translates into unfamiliarity, creating tension between convenience and anxiety. The present study thus addresses a critical gap: how can the logic of technology be reframed through the logic of human experience?

Age-Friendly Design originates from universal-design theory and aims to minimize cognitive and physical burdens through inclusive strategies. With the rise of the “silver economy,” research on aging has expanded from physiological adaptability to psychological cognition and emotional experience. Studies show that older adults commonly experience technology anxiety and perceived complexity, requiring stronger sensory cues and positive feedback to build trust with intelligent systems [3].

Within the smart-kitchen context, relying solely on interface optimization cannot yield a holistic experience. The integration of Service Design and Experience Design provides a systemic approach to complex user experiences. Service design focuses on the coordination among people, artifacts, and processes across service touchpoints and front-stage/back-stage interactions, while experience design emphasizes individuals’ sensory and emotional responses such as pleasure, safety, and trust. The combination enables a balance between system efficiency and emotional resonance. Guided by this synthesis, the present study constructs a three-layer experiential model—Perception–Interaction–Feedback—to serve as the theoretical foundation for subsequent analysis.

3. Research Methodology and Design Approach

3.1 Methodological Position: The Convergence of Service and Experience Design

Traditional user research tends to focus on functional matching—measuring task completion time, error rates, and interface layout efficiency. For older users, however, such quantitative indicators fall short, as their experience is shaped more by psychological safety and a sense of respect. This study therefore adopts an interdisciplinary methodology combining service design’s systemic

view with experience design's human sensitivity. Service design helps visualize the system network of devices, environments, users, and services, while experience design reveals the subtle emotional dynamics during interaction. We hypothesize that if technological services are reframed as companionship-based interactions, acceptance among older adults will rise significantly—this hypothesis anchors the subsequent design process.

3.2 Research Process: From “Being Heard” to “Wanting to Speak”

In the first stage, semi-structured interviews and contextual observations were conducted with 28 participants aged 60–75. Instead of focusing on functional requirements, the interviews asked: What do you most enjoy doing in the kitchen? When does technology feel unnecessary? The responses converged on three emotional needs: trust, control, and companionship—which became the affective dimensions of the service-experience model.

In the second stage, a user-journey map was developed using service-design tools, covering three major phases: preparation, cooking, and cleaning. Fifteen touchpoints and six recurring anxiety sources were identified, including speech-recognition failure, uncertain cooking status, delayed feedback, impersonal language tone, illogical lighting changes, and lack of closure confirmation. These were synthesized into experience breakpoints and informed the design of a multimodal “Perception–Interaction–Feedback” logic, enabling the system to respond proactively rather than reactively—what we term gentle anticipation.

3.3 Design Validation: The Skeptic’s Test

A hypothetical skeptic might ask: Can a few softer prompts and warmer tones truly change an older user’s experience? To answer this, we conducted a prototype validation experiment. Two systems were built:

Control group: a conventional command-based voice system;

Experimental group: an optimized system integrating contextual semantic recognition and affective feedback.

Thirty older participants completed identical cooking tasks under both conditions. The results were revealing: the most notable difference was not in task duration but in the rise of trust and companionship. 82% of participants described the system as “a helper rather than a tool,” and 71% expressed willingness to reuse it. These findings support our hypothesis that affective multimodal feedback is perceptible and fosters trust and engagement.

3.4 User Journey Analysis: Mapping the Path from Tasks to Emotions

To further understand real-world experience, a Customer Journey Map was constructed based on interview and observation data, spanning the stages of Preparation–Cooking–Cleaning. Fifteen service touchpoints and six major pain points were identified. The journey revealed a non-linear process intertwined with emotion and cognition.

During preparation, users emphasized the need for clear initiation and system responsiveness; failures in voice commands led to a sense of being ignored.

During cooking, emotional fluctuation was most pronounced: delayed or mechanical responses induced loss of control, while soft verbal cues and lighting adjustments restored calm.

During cleaning, users desired explicit confirmation that devices were safely turned off—a closure that grants psychological reassurance.

Three emotional trajectories emerged: (1) cautious engagement → (2) anxiety–trust fluctuation → (3) attachment and relief.

Correspondingly, three critical touchpoints were defined:

- (1) Initiation touchpoint – builds confidence;
- (2) Execution touchpoint – reinforces trust and immersion;
- (3) Feedback touchpoint – ensures emotional closure and reuse intention.

Based on high-anxiety touchpoints, three design interventions were proposed: dual-channel (voice + visual) confirmation at initiation, rhythmic and empathetic feedback during execution, and context-aware closure reminders at the end. These strategies directly informed the prototype configuration tested in the experiment.

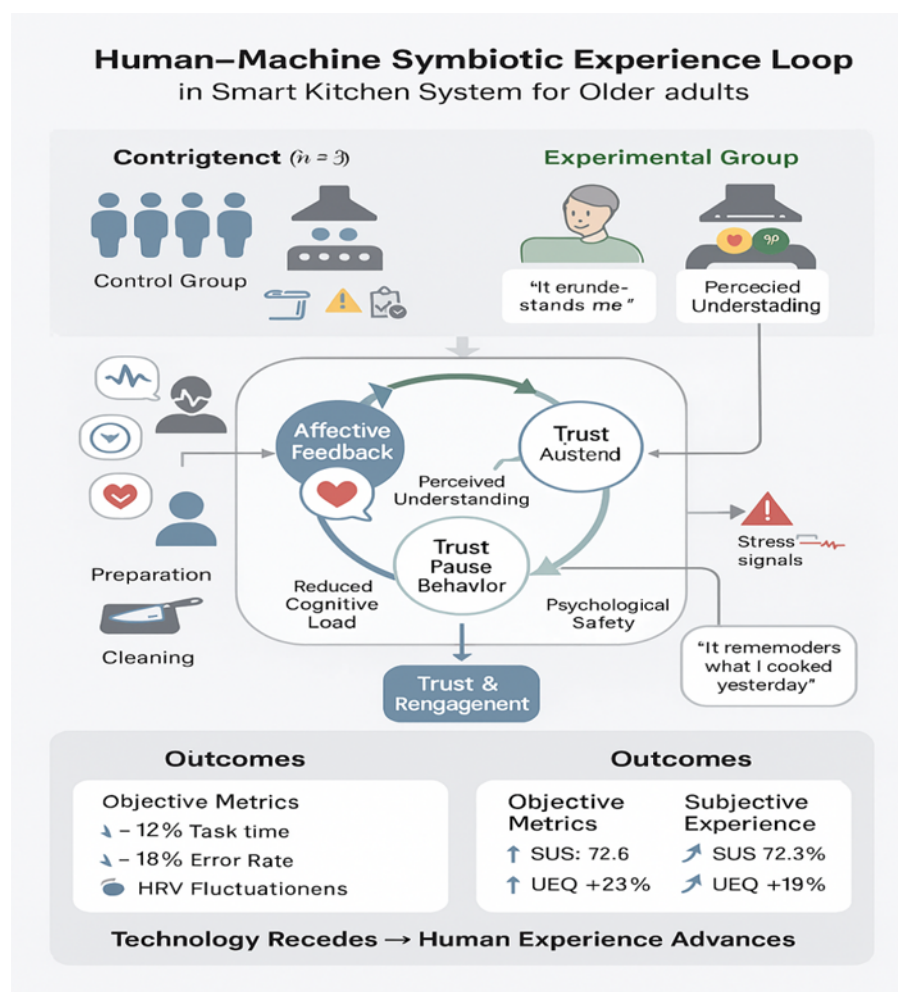


Figure 1: Human-Machine Symbiotic Experience Loop.

4. Empirical Study and Results Analysis

The experiment aimed to verify the framework's effectiveness in enhancing older users' experience. Thirty participants aged 60–75 were divided into a control group (commercial smart-kitchen system) and an experimental group (prototype integrating multimodal affective feedback). Each participant performed three tasks—preparation, cooking, and cleaning—under controlled laboratory conditions simulating a real kitchen. Objective indicators (task time, error rate, system latency, heart rate variability) and subjective measures (SUS and UEQ scores, interview data)

were collected.

Results show moderate efficiency gains (–12% task time, –18% error rate) but far greater improvement in experiential dimensions. System Usability Scale (SUS) scores increased from 72.1 to 83.6 ($p < .01$). In the User Experience Questionnaire (UEQ), Trust and Pleasure dimensions rose by 23% and 19% respectively ($p < .01$). Behavioral observation revealed reduced hesitation and a stronger pattern of Trust Pause—users waited calmly for system response instead of repeating commands, indicating reconstructed psychological safety. Physiological data further supported this: during high-cognitive-load phases, heart-rate and electrodermal fluctuations were markedly lower in the experimental group, confirming that affective feedback mitigates operational stress.

Qualitative findings provided richer insight. Many participants personified the system, saying, “It understands me,” or “It remembers what I cooked yesterday.” This illusion of being understood, though a design-driven perception rather than actual cognition, became a key psychological mechanism fostering trust and continued engagement. The optimal smart-kitchen experience, therefore, is not one dominated by technology but one where technology gracefully recedes—allowing users to refocus on life itself. These findings validate the proposed Human – Machine Symbiotic Experience Loop: technology understands humans → humans trust technology → technology better serves humans. When understanding is perceived, the relationship evolves from usage to coexistence.

5. Conclusion and Outlook

Centering on older adults, this study constructed and empirically verified a three-layer Perception–Interaction–Feedback model and an Affective-Driven Service Optimization Framework for smart kitchens. Findings confirm that integrating multimodal interaction and affective feedback at critical touchpoints can significantly enhance users’ trust, sense of control, and psychological safety—without altering the functional workflow.

Theoretically, the study extends the boundary of age-friendly design and smart-home research by emphasizing emotional regulation as a core component of service systems. Practically, it offers actionable strategies for system designers, including service-blueprint coordination, multimodal interface integration, and affective feedback mechanisms. The results further reveal that the most effective smart-kitchen experience lies not in visible technology, but in technology’s graceful retreat and emotion’s attentive presence.

Future research will expand sample diversity and contextual scope, testing the framework’s adaptability in senior-living communities and multigenerational households. Moreover, by integrating artificial intelligence and affective computing, the smart kitchen may evolve into an emotionally perceptive domestic node capable of empathetic interaction and proactive care. Ultimately, true intelligence lies not in algorithmic precision but in the warmth of understanding—when technology learns to listen, a symbiotic and compassionate smart life can truly emerge.

Disclosure statement

The author declares no conflict of interest.

Author contributions

Jiaying Li was solely responsible for the conceptualization and design of the study, the data

collection and analysis, as well as the drafting and revision of the manuscript.

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