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COMPANIONSHIP LIGHTING

A MULTI-SENSORY COMPANION LIGHTING SYSTEM FOR SOCIAL CONNECTION

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ABSTRACT

This study addresses the critical lack of emotional support and the persistent need for non-intrusive companionship in modern society. The design challenge is framed by the observation that fear of rejection creates a vicious cycle where individuals avoid initiating social contact. The research seeks to develop a low-burden mechanism that lowers the psychological threshold for seeking companionship, moving beyond the functional limitations of typical digital interactions.

The research employed a mixed-methods approach, combining quantitative Kansei Engineering Type II analysis with qualitative study. The Semantic Differential (SD) method was used to assess the emotional attributes of 15 existing lamp designs. Qualitative analysis of five high-performing samples (S3, S6, S7, S8, S11) deconstructed material and formal strategies. Both results informed the development of a prototype: a warm-toned LED lighting fixture with a mobile application offering touch-to-signal online status and conditional one-touch invitations for shared activities.

Principal Component Analysis identified three factors explaining 90.85% of variance: Natural Warm Atmosphere (68.42%), Comfort (16.00%), and Ceremony and Quality (6.43%). Critically, Have Companion–Lonely loaded strongly (0.867) within Natural Warm Atmosphere, revealing that companionship perception correlates with material naturalness rather than technological features. Qualitative analysis revealed existing companion lamps face a fundamental trade-off: designs maximizing natural warmth (soft materials, compact scale ≤7cm) lack ceremonial gravitas, while ceremonial designs feel commercial. The prototype occupies this strategic gap through handmade paper clay base (≤7cm) for tactile approachability with hand-blown frosted glass for perceived craftsmanship. This research offers three actionable principles: (1) material naturalness may be more important than technological interactivity for companionship perception, (2) physical constraint enables ritual integration when paired with premium material quality, and (3) ambiguous availability cues eliminate social friction while preserving user autonomy.

Keywords: Emotional Design, Kansei Engineering, Multi-sensory Interaction, Companionship

1 INTRODUCTION

According to the World Health Organization, approximately one in six people globally is currently affected by loneliness, a phenomenon that has significantly impacted physical and mental health. Although digital communication technologies have achieved unprecedented

density in information connection, individual loneliness has not decreased; instead, it presents the paradox of being "Alone Together" (Turkle, 2011). Existing Instant Messaging (IM) and video conferencing tools, while efficient, often impose high cognitive loads and social anxiety. This "always-on" mode of interaction is frequently perceived as an intrusive disturbance, failing to convey non-verbal companionship.

To address these challenges, this study proposes "SyncLight," a hybrid system integrating an interactive lamp with a low-burden social application. The design aims to balance personal solitude with social connection by allowing lighting behavior to signal availability without verbal intrusion. This paper details the system's architecture and investigates its perceived value as a ritual-oriented mechanism through qualitative interviews and prototype testing.

2 LITERATURE REVIEW

2.1 Remote Companionship and Ambient Mediation Technologies

The paradigm of remote interaction has evolved from functional information transmission toward the cultivation of affective relatedness. Hassenzahl et al. (2012) posited that contemporary technology design must transcend data exchange to mediate psychological proximity. Brave et al. (1998) introduced synchronized distributed physical objects, wherein virtual signals are materialized into tactile forms. Rieger (2019) demonstrated through LumiTouch how tactile gestures translate into ambient light patterns, enabling sustained emotional bonding under low-effort conditions.

2.2 Social Initiation Friction and Low-Burden Interaction Design

Despite ubiquitous connectivity, the psychological friction of social initiation persists. Turkle (2011) articulated the paradox of "alone together," wherein individuals gravitate toward controlled companionship that minimizes social vulnerability. This intensifies among populations with elevated fear of negative evaluation (Iqbal, 2019). Birnholtz et al. (2010) argued that effective design must incorporate ambiguous availability cues—signals conveying presence without demanding immediate response.

2.3 Ritual Design and Temporal Engagement

Ozenc and Hagan (2018) demonstrated that ritual design—structured interactive behaviors with symbolic meaning—effectively regulates affect. Operationalizing technological engagement as daily ritual confers biomimetic vitality upon objects, reframing digital connectivity as long-term symbiotic relationships.

3 METHODS

This study employs a Mixed-Methods Research Design, combining quantitative Kansei Engineering Type II (KE-II) with qualitative analysis. The study follows a four-phase framework: (I) Product Analysis, (II) Quantitative Kansei Engineering Analysis, (III) Prototype Implementation, and (IV) Qualitative Validation.

3.1 Phase I: Product Analysis

A systematic collection of 30 existing lamp designs was conducted using keywords such as 'aroma lamp,' 'mood lighting,' and 'therapeutic lighting.' Through selection criteria ensuring high diversity, 15 representative lamp designs (S1 to S15) were selected as stimuli.

Bipolar adjective pairs were systematically compiled from three research domains: lighting semiotics (Albertazzi, 2018; Castilla et al., 2018), olfactory affective space (Delplanque et al., 2012; Ferdenzi et al., 2013), and cross-modal environmental perception (Zuo et al., 2023). An initial pool of 20 pairs was reduced to 10 through pilot testing with 5 participants, selecting pairs with highest discriminatory power and lowest inter-correlation ($r < 0.70$).

The final set comprised four perceptual dimensions: Color Temperature (Warm–Cold, Soft–Dazzling), Emotional (Safe–Anxious, Relaxing–Stimulating), Context (Homely–Commercial, Natural–Artificial, Have Companion–Lonely), and Overall Experience (Comfortable–Uncomfortable, Ceremonial–Non-Ceremonial, Cheap–Expensive).



Figure 1. *Sample items representing three clusters (Natural, Metal Technology, Mixed)*

3.2 Phase II: Quantitative Kansei Engineering Analysis

The target audience comprised adults aged 25-34 years (70%) and 18-24 years (26.6%), aligning with urban workers experiencing high stress and loneliness. Thirty participants rated the 15 lamp images based on 10 bipolar adjective pairs using a seven-point Semantic Differential scale.

The unit of analysis was the lamp sample: for each of the 15 samples, ratings were averaged across the 30 participants on each adjective pair, yielding a 15 (samples) × 10 (adjective pairs) mean-score matrix. Principal Component Analysis (PCA) was then performed in SPSS on the correlation matrix of the 10 adjective pairs, applying Varimax rotation with Kaiser normalization to reduce dimensionality.

3.3 Phase III: Prototype Implementation

Based on quantitative findings, the SyncLight prototype integrates hardware and software to occupy the identified market gap.

Adjective Pair	Factor 1	Factor 2	Factor 3

Natural–Artificial	.950	.001	-.231
Homely–Commercial	.924	.266	.033
Have Companion–Lonely	.867	.159	.115
Comfortable–Uncomfortable	.294	.936	.165
Ceremonial–Non-Ceremonial	.211	.199	.881

Table 1. *Rotated Component Matrix (Selected Loadings >0.80)*

Factor 1 is dominated by Natural (.950), Homely (.924), and Have Companion (.867). Factor 2 is defined by Comfortable (.936). Factor 3 is characterized by Ceremonial (.881).

Sample	Image	Factor 1	Factor 2	Factor 3	Material
S6		+1.43	+0.98	-0.76	Soft felt
S7		+1.69	+1.69	-0.38	Concrete + amber glass
S8		+1.01	+0.58	-0.73	Stone-like translucent
S11		+1.58	-0.53	+1.36	Embossed paper
S3		-0.63	-0.14	+1.65	Faceted glass

Table 2. *Sample Coding Analysis showing factor scores for five high-performing samples*

Qualitative analysis of five high-performing samples revealed material strategies: S6 and S7 maximized natural warmth and comfort through soft materials, while S3 and S11 achieved high ceremonial quality through premium materials. This exposed a strategic gap: no existing product simultaneously achieves high scores across all three factors.



Figure 2. *Prototype combines stone-like base (paper clay) for natural warmth + hand-blown frosted glass for premium craftsmanship*

Hardware Design. The prototype employs handmade paper clay base (maximum 7cm height) mimicking natural stone texture, addressing Factor 1 attributes (Natural: 0.950, Homely: 0.924, Safe: 0.883). Hand-blown frosted glass diffusers provide soft light distribution (Soft: 0.865, Comfortable: 0.936). Integrated scent diffusion enhances multi-sensory relaxation. Warm-toned LED (2700-3000K) with breathing rhythm supports emotional regulation.

Software Design. The SyncLight mobile application comprises four modules: (1) Touch-to-Online Status Synchronization - tapping the lamp updates online status visible to friends; (2) Conditional One-Touch Invitation - activity invitations appear only when both parties are mutually online, eliminating rejection fear; (3) Companion Growth System - gamifies engagement through digital pet metaphor where the lamp grows with interaction frequency; (4) Shared Time Visualization - displays companionship through rankings and usage calendar.



Figure 3. *App screens showing (left) online status synchronization, (center) companion rankings, (right) usage calendar*

3.4 Phase IV: Qualitative User Validation

Semi-structured interviews with 7 participants followed a dual-phase process: (1) Blind Test—intuitive perception without functional explanation; (2) Contextual Inquiry—re-evaluation after understanding design logic. Interview procedure included: product demonstration, tactile interaction (10-20 seconds), feature introduction, semi-structured interview, and design feedback. Analysis employed thematic coding and affinity diagramming.



Figure 4. *(left) Tactile interaction during blind test, (right) Affinity diagramming process*

4 RESULTS

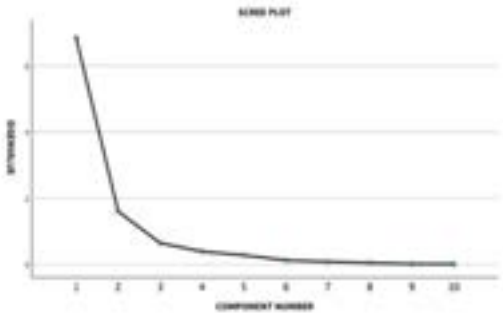
4.1 Kansei Engineering Findings

Three components were retained based on the scree-plot elbow (Figure 5) and interpretability, the third capturing a theoretically important Ceremony/Quality dimension despite an eigenvalue slightly below 1.0. The three components collectively explain 90.85% of total variance.

Component	Total	% Variance	Cumulative %	% Variance	Cumulative %
1	6.842	68.417	68.417	68.417	68.417
2	1.600	16.002	84.420	16.002	84.420
3	0.643	6.428	90.847	6.428	90.847

Table 3. *Total Variance Explained by Principal Component Analysis*

Factor 1 (Natural Warm Atmosphere) accounts for 68.42% of variance with an eigenvalue of 6.842. Factor 2 (Comfort) contributes 16.00% (cumulative 84.42%), and Factor 3 (Ceremony and Quality) adds 6.43% (cumulative 90.85%).



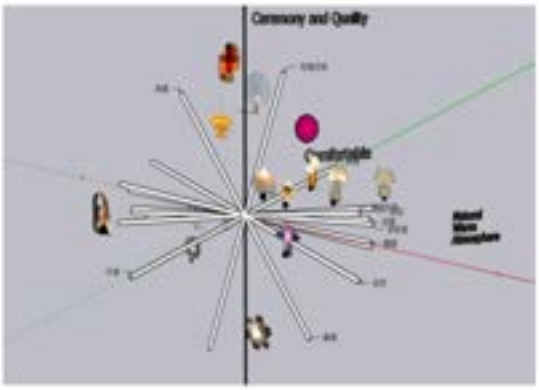


Figure 5. *Scree plot with clear elbow at component 3* ***Figure 6.*** *Positioning map (pink circle)*

4.2 Strategic Positioning Gap

Multi-dimensional scaling visualized the positioning of 15 lamp samples within the three-factor space. The analysis revealed a unique market gap (pink circle in Figure 6) combining high Natural Warm Atmosphere, Comfort, and Ceremony/Quality—largely unoccupied by existing products. High-natural lamps (felt, paper materials; ≤7cm) lacked ceremonial quality. Ceremonial lamps (glass, metal; complex forms) felt commercial rather than homely.

4.3 User Interview Themes

Thematic analysis identified four major themes:

Theme 1: Materiality of Interaction. Natural, tactile materials create emotional grounding and therapeutic value. Participants valued materials providing both tactile comfort and symbolic connection to nature. Warm color temperature (2700K) was universally preferred; breathing pattern creates "living presence." Scent was valued as optional enhancement, not core feature.

Theme 2: Social Connection Design. Critical finding: dual-mode functionality essential—some users require solitary operation without social pressure. User 7 emphasized: "Product should work without app dependency... Some need to be comfortable alone first." Conditional invitation mechanism effectively reduces rejection anxiety. Users demand high degree of control over social availability and growth features.

Theme 3: Form and Aesthetic Preferences. Small, rounded forms perceived as friendly and approachable, aligning with research on curved visual preference (Bar & Neta, 2006). The compact scale (≤7cm) was identified as optimal for bedside placement. Handmade, unique bases significantly increase emotional attachment through the IKEA effect (Norton et al., 2012).

Theme 4: Engagement and Retention. Critical problem identified: users with no existing friends on platform lack engagement drivers. Proposed solutions include workshop onboarding (participants automatically connected) and standalone value (lamp remains functional without social features). User 1 noted: "Options within options" allowing users to modulate engagement level based on life circumstances.



Figure 7. *Typical evening usage scenarios illustrating SyncLight in bedroom contexts*

5 DISCUSSION

This research makes three key contributions to companion-oriented design:

Material Naturalness May Be More Important than Technological Interactivity. The finding that "Have Companion–Lonely" loaded strongly (0.867) within Natural Warm Atmosphere—rather than forming an independent factor—suggests that digital interactivity may not be the primary driver of companionship perception. Since technological interactivity was not a directly measured variable in the quantitative study, this interpretation should be treated as tentative; nevertheless, qualitative analysis confirmed users seek objects that "co-exist" rather than "respond." This suggests designers should invest in tactile craftsmanship before adding smart features.

Physical Constraint as Ritualization Asset. Competitive analysis revealed high-natural lamps were constrained to soft materials and ≤7cm height, limiting ceremonial perception. The SyncLight prototype reframes compact scale as enabling intimate ritual integration. Pairing small dimensions with premium materials (hand-blown glass) resolves the naturalness-ceremony trade-off. The ≤7cm dimension positions the lamp as a bedside companion—small enough to not dominate space yet substantive enough to command daily attention.

Ambiguous Availability Cues for Social Friction Reduction. The conditional mutual-visibility mechanism transforms social initiation from explicit request (vulnerable to rejection) into background presence awareness. Unlike traditional IM systems where users must actively message and risk rejection, SyncLight's touch-to-online mechanism broadcasts availability passively. Activity invitations appearing only when both parties signal presence eliminates fear of "bothering someone" while preserving user autonomy.

Limitations. This study has several limitations. First, the sample size for qualitative validation (7 participants) is relatively small. Longitudinal studies tracking sustained engagement over months are necessary to validate the companion growth system's effectiveness. Second, the study focused on Taiwanese young adults; cross-cultural validation is needed. Third, the cold-start problem requires practical solutions before commercial deployment—workshop-based onboarding or social seeding strategies warrant further investigation.

6 CONCLUSION

This study addressed the challenge of designing companion technologies that reduce loneliness without imposing social burden. Through mixed-methods analysis, we identified a strategic market gap where no existing product simultaneously achieves natural warmth,

comfort, and ceremonial quality. The SyncLight prototype occupies this position through material strategy (handmade paper clay + hand-blown glass) and interaction design (conditional mutual-visibility + one-touch invitations).

Key findings challenge prevailing assumptions: (1) companionship perception correlates strongly with material naturalness (0.867), suggesting that material naturalness may be more important than interactive complexity; (2) physical constraint (≤7cm) enables ritual integration when paired with premium materials; (3) ambiguous availability cues eliminate social friction while preserving autonomy. These principles offer designers a replicable framework for creating emotionally resonant companion artifacts.

Three design principles emerge: Natural Materials and Tactile Qualities—designers should select materials with warm, natural surfaces (wood, stone, ceramic, fabric) providing psychological safety. Multi-Sensory Interaction—combining visual (warm light), tactile (natural surfaces), and olfactory (aromatherapy) experiences enhances relaxation. Light Design—warm-toned light (2700-3000K) and slow breathing rhythms (12+ seconds/cycle) support emotional grounding. Supplementary principle: Design for Autonomy—products should function without app dependency; all connectivity and gamification features should be toggleable.

As loneliness escalates as a global health crisis, the design community bears responsibility for creating technologies fostering genuine connection. This research contributes actionable design principles grounded in empirical evidence, offering a path toward companion technologies that truly serve human emotional needs.

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