Application Study of ADHD Design Based on Kano-QFD-Z-Pareto Methods

Zixiang Feng[a]; Yiwei Mo[b]*; Zhaochuan Fang[a]; Wenjinhan chen [a]

[a] Royal College of Art, London, United Kingdom

[b] Hubei Institute of Fine Arts, Wuhan, China

* moyiwei0426@gmail.com

In the past and current research and design practices, individuals with ADHD are predominantly defined as “patients,” with most design efforts focusing on the normalization needs of children and adolescents. However, there remains a significant gap in addressing the everyday and social support needs of adults with ADHD. This study adopts the lens of neurodiversity to explore the intersection of social and personal needs among adults with ADHD. By integrating the Kano-QFD-Z-Pareto methodology, the research systematically identifies and translates user needs into actionable design elements. Through a comprehensive literature review and Kano model analysis, 17 core user needs were extracted and categorized. A Quality Function Deployment (QFD) matrix was constructed to map the relationships between user needs and functional requirements, while Z-score normalization and Pareto analysis were employed to prioritize seven key design features, including gesture-based quick note-taking and stress-responsive relaxation suggestions. Based on these findings, a wearable smart device was developed, incorporating gesture-triggered voice transcription, a rotation-based anxiety relief module, and an AI-powered task optimization system. The device utilizes tangible interaction to reduce cognitive load and enhance attentional regulation and creative expression for individuals with ADHD. We advocate for a shift in the academically dominant design paradigm from a deficit-oriented approach to a function-supportive one, and propose a practical framework grounded in the principles of neurodiversity. This framework aims to advance inclusive design practices and foster further academic research in this field.

Keywords: Attention-Deficit/Hyperactivity Disorder； Neurodiversity； Kano-QFD model； Wearable devices

1 Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD) was first proposed in 1902 by British pediatrician Sir George Still and has since been widely recognized as a neurodevelopmental disorder. Its core symptoms include inattention, impulsivity, and hyperactivity. These characteristics are especially prominent during childhood and adolescence, often resulting in difficulties in adapting to educational settings (Chacko et al., 2024; Daley et al., 2009). Individuals with ADHD may exhibit behaviors such as difficulty focusing, restlessness, frequent questioning, or susceptibility to environmental distractions.

In recent years, treatment for ADHD has increasingly adopted a multimodal intervention strategy, including pharmacological treatment ((Abdullah Abaoud 2022); Volkow et al., 2007), psychological counseling (Merrill et al., 2024; Hu et al., 2025), behavioral interventions (DuPaul et al., 2024; Abaoud, 2022), and EEG biofeedback (Maurizio et al., 2014; Cheng et al., 2024), among others (Arns et al., 2014).

Although research on ADHD has grown considerably (Klingberg et al., 2005; Weisberg et al., 2014), both intervention strategies and public discourse still tend to focus predominantly on childhood manifestations, with limited attention paid to adult ADHD (Faraone et al., 2006). As a result, the lived experiences and specific needs of adults with ADHD are often overlooked. While approximately 5–7% of children worldwide are estimated to have ADHD (Polanczyk et al., 2007), recent studies suggest that ADHD entails a persistent cognitive difference that continues into adulthood. A multinational study by Graaf and co-workers estimated the global prevalence of adult ADHD to be between 2.5% and 4%, with most individuals undiagnosed or lacking adequate social support, leading to serious workplace maladaptation (Graaf et al., 2008), elevated risks of comorbid psychological disorders, and impaired family functioning (Dalsgaard et al., 2015). Adults with ADHD are also more likely to experience higher absenteeism rates, decreased productivity, and emotional volatility in the workplace (Graaf et al., 2008), exacerbating social marginalization and revealing a significant gap in research focused on their normalized, functional needs.

This study responds to the emerging shift in research paradigms toward “de-medicalization” and the recognition of “multiple cognitive identities.” It rejects the pathologizing view of individuals with ADHD as merely patients in need of correction and instead adopts a sociological perspective grounded in the theory of neurodiversity. From this standpoint, individuals with ADHD are regarded as neurodivergent users with distinct functional needs and cognitive preferences.

Accordingly, we developed an integrated Kano-QFD-Z-Pareto model, combining the Kano model for requirements classification, Quality Function Deployment (QFD) for matrix construction, Z-score standardization, and Pareto analysis. This model aims to systematically uncover the actual needs of adults with ADHD in the domains of social participation and workplace integration. Through this process, we constructed a user requirements–technical features mapping matrix to identify the key points of convergence between user expectations and design responses. The ultimate goal is to propose inclusive and practical product design strategies. Based on the findings from our user needs research, we further developed a conceptual assistive device prototype.

At the practical level, this study provides a novel method for acquiring user needs tailored to the design of medical assistive devices for individuals with ADHD. It introduces new possibilities for design translation and expands the practical field’s understanding of the deeper, non-clinical needs of ADHD users that have previously remained unexplored. At the theoretical level, this research offers a new perspective on ADHD user needs, encouraging scholars to shift design thinking from a focus on “treatment and correction” toward “functional support and social integration.”

2 Literature review

2.1 ADHD-related research

Early research on Attention-Deficit/Hyperactivity Disorder (ADHD) was confined to the domains of clinical medicine and psychiatry, with an emphasis on describing hyperactivity and inattention in children and implementing pharmaceutical interventions. However, advances in psychology and neuroscience have revealed that ADHD is not merely a behavioral issue but a neurodevelopmental disorder involving deficits in executive functions and neurochemical imbalances (Barkley, 1997). Based on this perspective, the design discipline began to reframe ADHD individuals’ reliance on structured environments and sensitivity to immediate feedback as key principles for assistive tool development. Early low-tech interventions—such as visual schedulers (colorful charts listing daily tasks), sticker-based reward systems (in which stickers are awarded for task completion), and time timers (featuring a red disc that gradually disappears to visually represent the passage of time) effectively reduce the working memory load of ADHD-assisted design by visualizing abstract concepts such as ‘time’ and ‘task’, and combining them with immediate positive reinforcement. By using these methods, the working memory load of users is effectively reduced, laying down the three principles of ADHD assisted design: abstract visualization, instant feedback mechanism, and cognitive load control (Douglas, 1972; Barkley, 2012; Abdullah et al., 2022).

With the widespread adoption of computers and mobile devices, ADHD interventions have gradually entered the digital and interaction design domain. Cognitive training software and neurofeedback games developed from the 1990s to the early 2000s demonstrated short-term improvements in attention during laboratory trials, but generally suffered from poor user adherence due to limited focus on user experience and engagement (Klingberg et al., 2005; Cortese et al., 2015). Since 2010, participatory design has been widely adopted in the development of ADHD assistive technologies. Researchers have collaborated with ADHD individuals and their families to co-define needs and iteratively develop prototypes. For example, the TangiPlan system transforms morning routines into tangible task cards, leveraging multimodal tactile and visual interactions to enhance execution compliance. The MOBERO app uses photo-based checklists and point-reward mechanisms to improve children's behavioral performance while reducing parental caregiving burdens. ChillFish gamifies deep breathing exercises by having users regulate a virtual character's movements to collect stars, enabling natural engagement with emotional self-regulation (Weisberg et al., 2014; Sonne et al., 2016; Sonne & Jensen, 2016; Abdullah et al., 2022).

Over the past few decades, a more systematic methodology has emerged for ADHD-related design. Scholars have emphasized that inclusive co-creation ensures that products align with real-world contexts. Through workshops and interviews, individuals with ADHD and their caregivers participate in in-depth needs exploration and prototype testing, significantly improving usability and long-term adherence (Abdullah et al., 2022). At the same time, minimalist interaction principles have been widely adopted in interface design: simplifying navigation hierarchies, using flat icons and neutral color schemes, and avoiding excessive dynamic elements to reduce the risk of distraction (Koutsabasis et al., 2021). In parallel, the development of multimodal and context-aware technologies allows assistive tools to deliver real-time alerts or behavioral strategies during episodes of inattention or emotional fluctuation. For example, wearable vibration devices detect and alert users about distraction, while the ParentGuardian system provides intervention prompts prior to potential parent-child conflicts, realizing a deep integration of "external executive assistance" and "just-in-time intervention" (Sonne et al., 2016).

Across education, healthcare, and daily life settings, ADHD assistive design is demonstrating increasing impact. In education, serious games such as EmoGalaxy embed emotional training into narrative-based tasks, improving engagement and enhancing emotional recognition and regulation skills. In the medical field, devices such as the Monarch eTNS use nighttime trigeminal nerve stimulation to alleviate symptoms, showcasing interdisciplinary integration between engineering and clinical practice. While several small-scale studies have validated the short-term effectiveness of these tools in improving attention and behavior, long-term follow-up studies and large-scale randomized controlled trials remain scarce. Furthermore, deeper integration of assistive tools into the family and school ecosystems is still needed (Faraone et al., 2024; Abdullah et al., 2022).

2.2 Kano model

Introduced by Kano et al. in 1984, this model provides a two-dimensional analytical framework that maps the relationship between product attributes and user satisfaction, offering a scientific basis for prioritizing functional features. Its core contribution lies in its innovative demand classification system, which categorizes product features based on users' reactions to their presence or absence. Specifically, must-be quality refers to baseline requirements whose absence results in strong dissatisfaction, though their fulfillment only maintains minimal satisfaction. One-dimensional quality exhibits a linear relationship between functionality and user satisfaction. Attractive quality represents unexpected or delightful features that significantly enhance user experience but do not cause dissatisfaction when missing. Indifferent quality has little to no impact on user perception regardless of its presence, while reverse quality refers to features that, when imposed, may detract from the user experience. This layered framework effectively addresses the ambiguity often found in traditional user requirement analyses (Kano et al., 1984), and has proven particularly adaptable in healthcare-related design contexts.

For instance, Gimpel and co-workers validated the effectiveness of the Kano model in identifying user satisfaction drivers through an empirical study on mobile health applications across multiple countries (Gimpel et al. ,2021). Although previous research has contributed valuable insights into health-related product design, systematic interaction design studies specifically targeting the ADHD user group through the Kano model remain limited. Therefore, this study adopts the Kano framework to systematically identify both core and latent needs of individuals with ADHD.

Positive	**Negative**				
Questions	**Favorite**	**Necessary**	**Indifferent**	**Reluctant**	**Disgusting**
Favorite	Q	A	A	A	O
Necessary	R	I	I	I	M
Indifferent	R	I	I	I	M
Reluctant	R	I	I	I	M
Disgusting	R	R	R	R	Q
A attractive, O one-dimensional, M must-be, Q questionable, R reversal, I indifferent					

Table 1. Kano Evaluation Table

2.3 Quality function deployment

Quality Function Deployment (QFD) is a user-centered, systematic product development methodology. Its core tool, illustrated in Figure 1, is the House of Quality (HoQ)—a bidirectional matrix used to map user needs ("What") to design features ("How"). By assigning weights to each user requirement and evaluating the strength of correlations with design elements, QFD enables the calculation of comprehensive priority scores for each design feature. This quantitative decision-support system helps guide product development strategies. The structure of the HoQ resembles a house: the roof represents the correlation matrix among design features, the left side lists user needs, and the right side may extend to include competitive benchmarking. As such, it is a key visual and analytical component of QFD.

QFD has demonstrated strong adaptability and practical value across a range of design and service domains. In consumer electronics, Montesinos-González and co-workers et al. applied QFD to continuously optimize the design of protective face masks in 2023, improving both wearing comfort and protective effectiveness (Montesinos-González et al.,2023). In furniture design, Lyu and co-workers utilized a Kano-QFD approach to analyze user expectations for smart office desks and determine feature priorities (Lyu et al. ,2022). In service systems, Sujiono and Krisnawati integrated SERVQUAL and QFD to assess hotel smart lock after-sales services, highlighting expectation–perception gaps and prioritizing proactive customer follow-up as a key improvement (Sujiono al. , 2025).

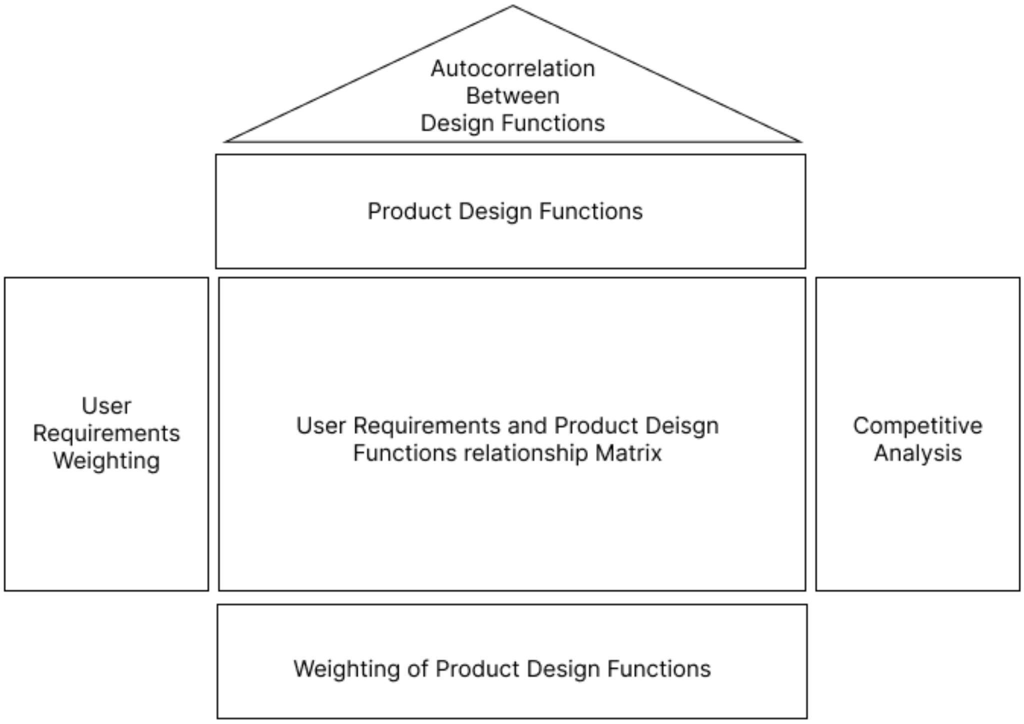


Figure 1. House of quality matrix

3 Research Methodology

To develop an assistive product design framework for individuals with ADHD (Attention-Deficit/Hyperactivity Disorder), this study adopts a four-stage systematic research strategy (as shown in Figure 2), including: user needs extraction, kano model attribute partitioning, QFD matrix construction, and design feature prioritization. The Kano–QFD–Z–Pareto model integrates qualitative analysis with structured decision-making tools. By combining the Kano model and Quality Function Deployment (QFD), and applying Z-score standardization analysis and Pareto analysis, a three-tiered design path is constructed with precision.

In the first stage, the study conducts a systematic literature review to identify typical challenges and behavioral characteristics faced by individuals with ADHD in daily life and product interaction scenarios. User needs are extracted from relevant studies, categorized, and coded to generate a preliminary list of requirements. This stage builds a user needs framework grounded in existing knowledge, providing theoretical support and content reference for subsequent empirical validation and design modeling. This step defines the problem space and establishes the evidence-based foundation for later quantitative analysis.

In the second stage, the Kano model is applied to classify the extracted user needs based on satisfaction attributes. A Kano questionnaire is developed and distributed to ADHD users and domain experts to collect emotional responses and satisfaction expectations regarding various functions. Based on the survey results, a Kano evaluation matrix is constructed to categorize user needs into five types: “Basic,” “Performance,” “Attractive,” “Indifferent,” and “Reverse.” This process not only reveals the nonlinear relationships between needs and satisfaction but also provides behavioral and psychological foundations for prioritizing design features, reinforcing the role of user participation in design decisions. This step links user psychology to measurable attributes, forming a data-driven basis for weighting and prioritization.

In the third stage, the user need attributes identified in the previous step are systematically translated into specific product functions using the QFD method. This stage includes the following steps: first, user needs are mapped to actionable design elements through functional decomposition; next, the importance of each need is weighted according to its Kano category and frequency; finally, a House of Quality matrix is constructed to analyze the correlation and influence strength between user needs and design features. This step acts as a bridge, converting abstract user expectations into concrete technical design elements.

In the fourth stage, the design parameter scores are first standardized using Z-score analysis and categorized into “Important,” “Secondary,” and “Optional” features based on thresholds ($Zi > 1$, $-1 < Zi < 1$, $Zi < -1$). Subsequently, the original scores are sorted in descending order, and a Pareto chart is generated to identify key functions contributing to the top 80% of cumulative importance. By integrating the results of both analyses, design features are classified into “Priority Design Features,” “Secondary Design Features,” and “Non-essential Features,” offering quantitative support for prototype development and resource allocation. This step filters noise and focuses resources on the critical few features that most impact user satisfaction.

Our research, by combining the Kano model with the QFD method and introducing Z-score standardization and Pareto analysis, addresses the subjectivity in selecting design features in conventional QFD approaches. It establishes a user-perception-driven and technically grounded design process, and applies it innovatively in the context of product design for individuals with ADHD.

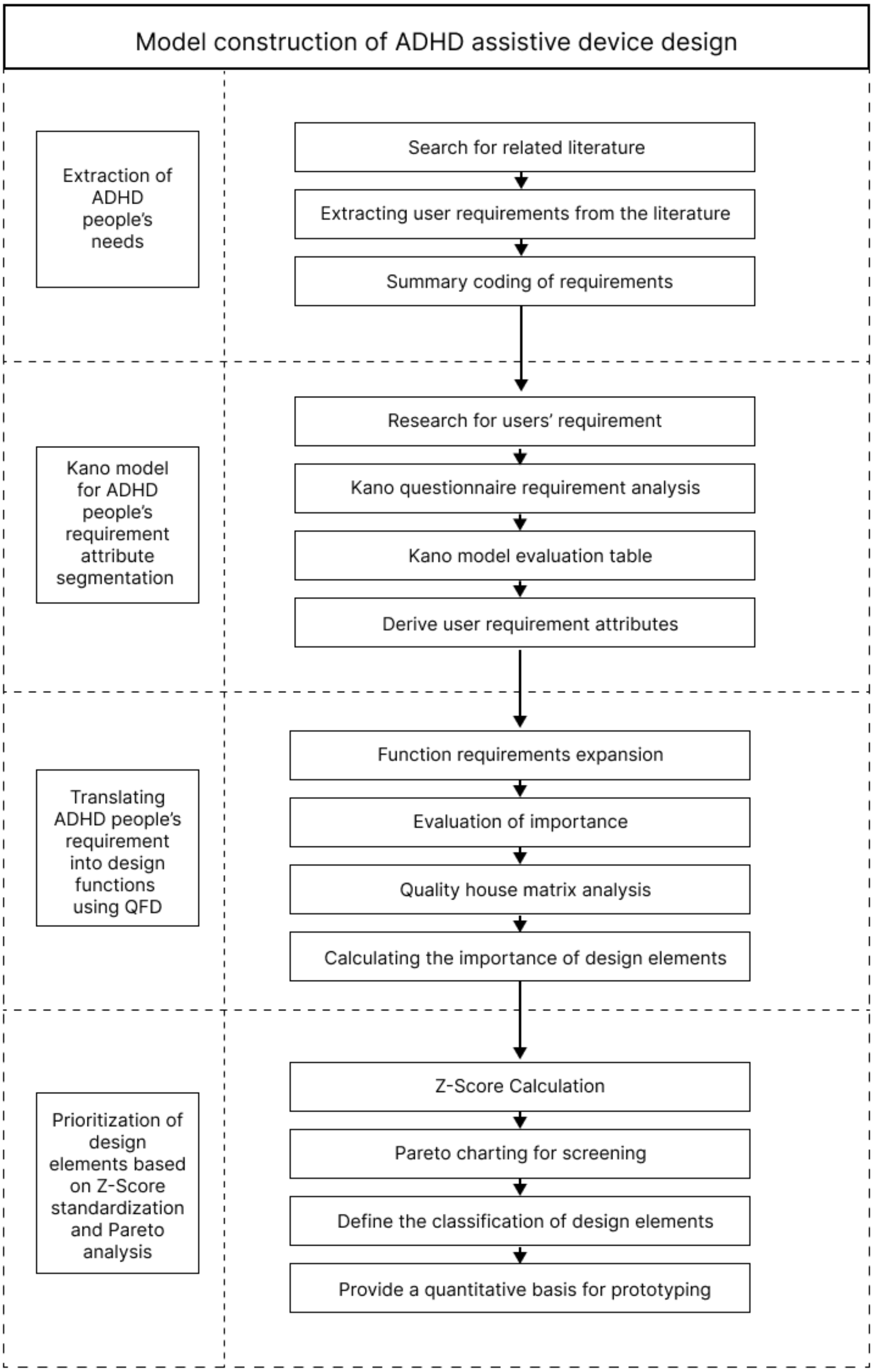


Figure 2. Research Methodology Model Composition Diagra

4 Results

4.1 Gathering User Requirements

To systematically identify user needs in the design of assistive products for individuals with Attention-Deficit/Hyperactivity Disorder (ADHD), Through an in-depth review of existing academic results and clinical practices, we were able to transform the fragmented requirements into 17 actionable user requirements, as summarized in Table 2. This provides a solid empirical foundation for the subsequent categorization of requirement attributes and technology mapping.

Firstly, the necessity for data storage and analysis (U7) is supported by studies conducted by researchers such as Păsărelu and Andersson (2020), whose findings have been further developed and expanded upon by subsequent scholars. For instance, Abdullah (2020) emphasizes that continuous digital monitoring of ADHD symptoms via mobile applications and smartphone sensors can yield critical insights essential for developing personalized intervention strategies. Similarly, the need for daily behavior tracking and analysis (U8) is derived from researchers, who found that ecological momentary assessment (EMA is a methodology whereby mobile devices deliver brief questionnaires to participants multiple times per day, enabling the real-time capture of their current experiences, attentional states, and contextual environments) and structured daily reports can significantly improve symptom recognition and self-regulation (Kennedy et al., 2022).

The need for emotion tracking (U9) is supported by Whalen and co-authors and Shaw and co-authors, who emphasized that real-time emotional assessments are critical for managing affective dysregulation in individuals with ADHD (Shaw et al., 2014). For attention enhancement (U10), Kollins et al. and Ayearst et al. demonstrated that gamified digital therapeutics and wearable reminder devices can improve sustained attention and task-related behaviors (Ayearst et al., 2023; Kollins et al., 2020).

In terms of creative productivity support (U11), White et al. (2006) highlighted the elevated divergent thinking capacity of individuals with ADHD, underscoring the need for tools that aid creative ideation and structure creative output. The need for personal efficiency improvement (U12) is supported by researchers, who found that interventions targeting organizational skills can significantly enhance academic and daily performance (Solanto et al., 2010).

The need for relaxation guidance (U13) is validated by Lin and co-authors and van de Weijer-Bergsma and co-authors, who reported that mindfulness-based practices can reduce core symptoms and associated stress in ADHD (van de Weijer-Bergsma et al., 2012). Likewise, emotion and stress regulation (U14) is emphasized by researchers, who found that cognitive-behavioral interventions for emotional regulation are important supplements to traditional ADHD treatment (Shaw et al., 2014).

For ADHD diagnosis and telehealth functionality (U15), Myers and co-authors and Higuchi co-authors provided robust evidence that telepsychiatry offers reliable assessment and ongoing management, making it a vital function in future digital systems (Tse et al., 2015). Similarly, the need for disease prevention and management (U16) is grounded in the clinical guidelines by Wolraich and co-authors and the early intervention framework proposed by Halperin and Schulz in 2016, both advocating early behavioral and cognitive management to reduce long-term impairments (Wolraich et al., 2019).

The need for fitness and physical activity support (U17) is confirmed by meta-analyses conducted by Neudecker et al. and Vysniauske et al., which show that structured physical activities improve executive function and motor skills in children and adolescents with ADHD (Vysniauske et al., 2016; Neudecker et al., 2015). The need for noise control and sound environment management (U18) originates from the work of Söderlund co-authors in 2007 and Zentall and Shaw in 1980, who found that controlling auditory environments (e.g., through white noise) can enhance cognitive performance in ADHD populations (Söderlund et al., 2007; Zentall & Shaw, 1980).

The need for context-aware feedback functions (U19) is supported by the conceptual framework of Just-in-Time Adaptive Interventions (JITAIs), as articulated by Nahum-Shani and colleagues (2018), which emphasize delivering the right type and amount of support at the right time by dynamically adapting to individuals' internal states and situational contexts in order to reduce vulnerabilities and foster positive behavior change. Furthermore, the importance of wearable and portable functionality (U20) is emphasized by Ayearst and colleagues in 2023 and by Begum and Poulakidas in 2018, who highlight the critical value of continuous mobile support in the management of ADHD (Ayearst et al., 2023).

The need for sensory interaction features (U21) is stressed by Sarver and colleagues in 2015 and Pfeiffer and colleagues in 2008, who suggest that controlled sensory stimulation—such as tactile engagement—can enhance attention and cognitive performance (Pfeiffer et al., 2008). The need for entertainment and leisure features (U22) is supported by the work of Bul and colleagues in 2016 and Kollins and colleagues in 2021, who found that gamified interventions and leisure-oriented designs significantly increase engagement and adherence among individuals with ADHD (Kollins et al., 2021). Finally, the importance of social and activity-based functions (U23) is affirmed by Ros and Graziano in 2018 and Mikami and colleagues in 2017, who demonstrated that structured peer activities and social skills training programs can substantially improve social competence and reduce isolation in individuals with ADHD (Ros & Graziano, 2018).

In summary, through a systematic review and empirical synthesis of recent literature, this study identifies and consolidates 17 core user needs for individuals with ADHD in the context of digital assistive product design. These needs span multiple dimensions, including attention regulation, emotional control, behavior monitoring, and social support. They not only reflect the symptomatic characteristics of ADHD but also highlight the potential of contemporary technological interventions in managing and improving ADHD-related outcomes.

Requirements classification	Requirement Details	Reference
User information collection and analysis function	Data Storage and Analysis	Păsărelu et al. (2020); Abdullah et al. (2022); Kennedy et al. (2022); Shaw et al. (2014)
	Daily Behavior Recording and Analysis	
	Mood Tracking	
Efficiency and creativity optimization	Focus Enhancement	Kollins et al. (2020); Ayearst et al. (2023); White & Shah (2006) Solanto et al. (2010); van de Weijer-Bergsma et al. (2012)
	Creative Work Enhancement	
	Personal Efficiency Enhancement	
	Relaxation Instruction	
Health management and improvement functions	Emotional and Stress Regulation	Shaw et al. (2014); Tse et al., (2015); Wolraich et al. (2019); Halperin & Schulz (2006); Neudecker et al. (2015); Vysniauske et al. (2016)
	ADHD Disease Diagnosis Function and Telemedicine Function	
	Disease Prevention and Management	
	Fitness and Motor Function	
Scene Sensing and Environment Adaptation	Noise control and management	Söderlund et al. (2007); Zentall & Shaw (1980);
	Context-Aware Feedback Function	Nahum-Shani et al. (2016)
Device form factor and interaction	Wearable and Portable Features	Ayearst et al. (2023); Pfeiffer et al. (2008)
	Sensory Interaction Function	
Social & Entertainment Functions	Entertainment & Recreation Functions	Kollins et al. (2021); Ros-Demarize & Graziano (2017)
	Social & Activity Functions	

Table 2. User requirements extraction

4.2 Kano model-based user requirement attribute classification

The Kano questionnaire serves as the foundational tool for categorizing user need attributes and determining importance rankings within the Kano model. Based on the 17 core user needs of ADHD users identified in the preliminary phase, this study designed a structured Kano questionnaire. Each need was presented in the form of a dual-factor five-point Likert scale, including both a positive and a negative question, to capture users' attitudinal responses toward the presence and absence of each function. Respondents were asked to choose from five options—"Like," "Must-be," "Neutral," "Live-with," and "Dislike"—to reflect their emotional and expectation levels for each function.

This study adopted an offline face-to-face survey method, with questionnaires distributed on-site at three universities in London, UK. The target participants included individuals aged 18 to 35 with ADHD diagnoses, self-identified ADHD individuals, as well as long-term companions or caregivers of ADHD users. Prior to the formal investigation, the research team conducted a pre-test of the questionnaire content, inviting five volunteers with ADHD backgrounds to complete the questionnaire and provide feedback on comprehension difficulty and wording clarity. Based on this feedback, adjustments were made to certain terms and scenario descriptions to ensure that all items aligned with the cognitive habits and expression styles of ADHD users.

During the questionnaire distribution, researchers provided on-site guidance to ensure participants fully understood the dual-question logic of the Kano model, in which each feature must be evaluated under both "presence" and "absence" conditions. If participants encountered ambiguous concepts or reading difficulties during completion, the researchers were allowed to assist with explanations, but not to intervene in their responses. All questionnaires were completed anonymously, and participant privacy was strictly protected. A total of 120 questionnaires were distributed, and 102 valid questionnaires were returned, yielding a response rate of 85%. The final sample consisted of 68 ADHD individuals (66.7%), 22 caregivers or long-term companions (21.6%), and 12 individuals without ADHD but with regular contact with ADHD users (11.7%). Among ADHD respondents, 54.4% were female (n = 37) and 45.6% were male (n = 31), with a mean age of 24.3 years (SD = 4.1). Regarding education level, 61.8% were undergraduate students, 28.4% were postgraduate students, and 9.8% were young professionals working in various industries. To ensure statistical reliability, SPSSAU software was used to perform a reliability test, and the Cronbach's alpha coefficient was found to be 0.824, significantly higher than the recommended threshold of 0.8, indicating that the scale possessed strong internal consistency and reliability for subsequent analysis.

In the analysis phase of the Kano model, each functional requirement was classified into one of five typical attributes—Must-be (M), One-dimensional (O), Attractive (A), Indifferent (I), and Reverse (R)—based on the combination of user responses to the positive and negative questions. Given that the Kano model relies on an "absolute concept" of classification, some needs showed a high proportion of responses falling into the "Indifferent" category. To enhance the sensitivity and explanatory power of the classification results, this study further introduced the Better and Worse coefficients to perform a refined analysis of the attributes under a “relative concept” framework by constructing a scatter quadrant diagram (see Table 3). The Better coefficient is calculated as Better = (A + O) ÷ (A + O + M + I), and the Worse coefficient as Worse = (O + M) ÷ (A + O + M + I) × (–1). Furthermore, the Customer Satisfaction Index (CSI) is calculated as $\text{CSI}_i = \max(|\text{Better}|, |\text{Worse}|)$. To assist in interpreting the perceived priority of each need, this study adopts both the Better and Worse coefficients, whose absolute values range between 0 and 1. A value closer to 1 indicates that the feature plays a stronger role in enhancing satisfaction or reducing dissatisfaction, while a value closer to 0 suggests lower perceived importance.

Finally, the 17 user needs were classified into four attribute types based on the coordinate distribution of their Better and Worse values in the quadrant diagram (see Figure 3): Quadrant I represents “One-dimensional” attributes, Quadrant II represents “Attractive” attributes, Quadrant III represents “Indifferent” attributes, and Quadrant IV represents “Must-be” attributes. This analysis not only addresses the limitations of traditional Kano classification in terms of precision for real-world design decisions but also provides a more interpretable data foundation for feature weighting in the subsequent QFD analysis.

User requirements	**M**	**O**	**A**	**I**	**R**	**Q**	**Better**	**Worse**	**C**
Data Storage and Analysis	3.92%	23.53%	23.53%	45.1%	0%	3.92%	48.98%	-28.57%	48.98%
Daily Behavior Recording and Analysis	0%	21.57%	39.22%	37.25%	0%	1.96%	54.9%	-25.49%	54.9%
Mood Tracking	0%	15.69%	37.25%	45.1%	1.96%	0%	54%	-16%	54%
Focus Enhancement	3.92%	27.45%	37.25%	31.37%	0%	0%	64.71%	-31.37%	64.71%
Creative Work Enhancement	5.88%	19.61%	35.29%	39.22%	0%	0%	54.9%	-25.49%	54.9%
Personal Efficiency Enhancement	3.92%	23.53%	39.22%	29.41%	0%	3.92%	65.31%	-28.57%	65.31%
Relaxation Instruction	0%	13.73%	41.18%	45.1%	0%	0%	54.9%	-13.73%	54.9%

Emotional and Stress Regulation	0%	19.61%	39.22%	39.22%	0%	1.96%	60%	-20%	60
ADHD Disease Diagnosis Function and Telemedicine Function	3.92%	9.8%	41.18%	45.1%	0%	0%	50.98%	-13.73%	50.98%
Disease Prevention and Management	1.96%	3.92%	23.53%	68.63%	0%	1.96%	28%	-6%	28%
Fitness and Motor Function	0%	5.88%	23.53%	66.67%	0%	3.92%	30.61%	-6.12%	30.61%
Noise control and management	0%	7.84%	43.14%	45.1%	0%	3.92%	53.06%	-8.16%	53.06%
Context-Aware Feedback Function	0%	13.73%	37.25%	45.1%	0%	3.92%	53.06%	-14.29%	53.06%
Wearable and Portable Features	3.92%	33.33%	27.45%	29.41%	3.92%	1.96%	64.58%	-39.58%	64.58%
Sensory Interaction Function	1.96%	11.76%	41.18%	41.18%	0%	3.92%	55.1%	-14.29%	55.1%
Entertainment & Recreation Functions	3.92%	0%	27.45%	64.71%	1.96%	1.96%	28.57%	-4.08%	28.57%
Social & Activity Functions	0%	9.8%	25.49%	62.75%	0%	1.96%	36%	-10%	36%

Table 3.Kano statistical results

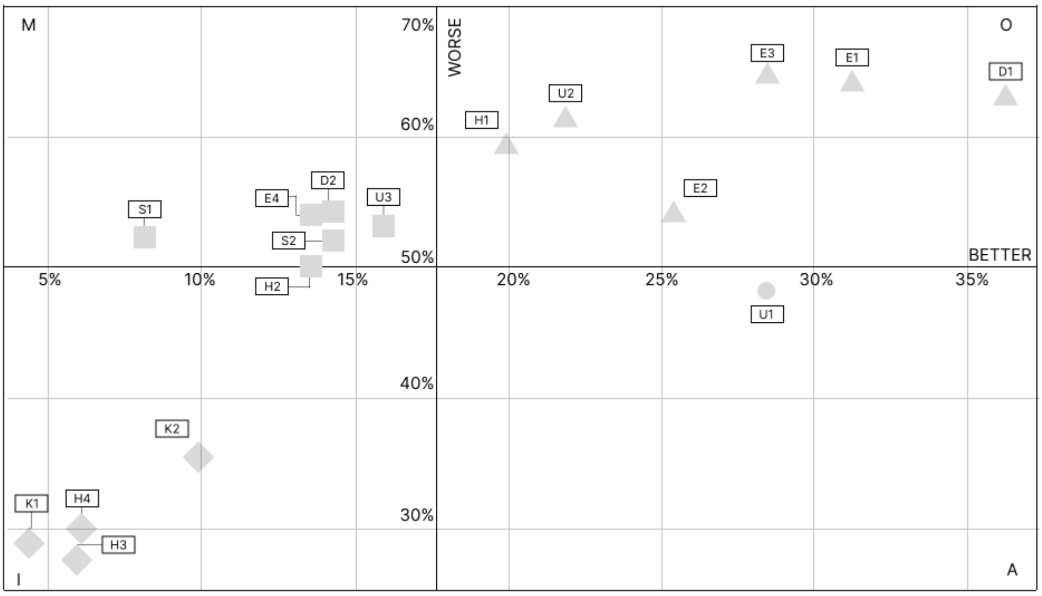


Figure 3. Better-Worse Quadrant Diagram of User Needs

4.3 Design element analysis based on QFD Methods

Building upon the identification and classification of core user needs for individuals with ADHD, this study further systematically translated these needs into actionable design parameters to provide quantitative support for product function planning and resource allocation. In this stage, the Requirement-to-Parameter Mapping Method was adopted. Based on the 17 previously identified user needs, and taking into account technological feasibility, behavioral support pathways, and interaction strategies, one-to-one or one-to-many mapping relationships were established between user needs and design parameters (see Table 4). Throughout this process, the study holistically considered the systemic logic between perceptual input, behavioral output, and technological implementation to ensure that the resulting design parameters are not only technically feasible but also offer high user adaptability and intervention value.

The House of Quality (HoQ), as the core structure of the Quality Function Deployment (QFD) method, was used to visually represent the strength of the relationship between user needs (WHAT) and design elements (HOW). User needs and their assigned weights were placed on the left side of the HoQ—commonly referred to as the “requirement wall”—while design parameters were positioned along the top “design matrix.” By constructing a user–technology relationship matrix, data-driven prioritization of functions was achieved, guiding the configuration of core modules and the allocation of resources throughout the product development process.

To enhance the objectivity and professionalism of relevance assessments, five domain experts were invited to participate in the matrix construction. These included two product designers, two physicians with experience in ADHD treatment, and one expert in design research. The expert panel assessed the correlation strength of each “user need–design parameter” pair based on their professional judgment, using the following symbols and scoring criteria: ◎ indicates strong correlation (5 points), ● indicates moderate correlation (3 points), △ indicates weak correlation (1 point), and a blank cell indicates no significant correlation (0 points).

To evaluate the relative importance of each design parameter in meeting user needs, this study followed the weighted scoring logic of QFD and used the following formula to calculate the design parameter weights:

$$\mathrm{W_j} = \sum_{\mathrm{i=1}}^{\mathrm{n}} \mathrm{R_{ij}} \times \mathrm{I_i}$$

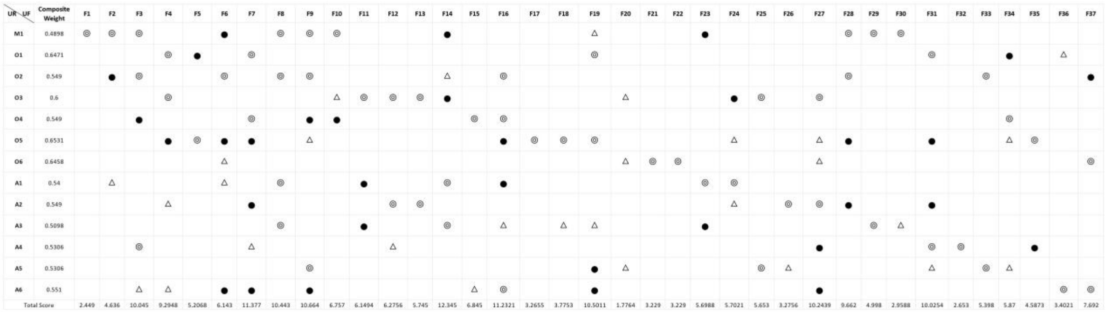
Where $\mathrm{W_j}$ represents the overall weighted score of the j-th design parameter; $\mathrm{R_{ij}}$ denotes the correlation score between the i-th user need and the j-th design parameter (with possible values of 5, 3, 1, or 0); and $\mathrm{I_i}$ indicates the importance weight of the i-th user need, derived from a combination of the Kano model’s satisfaction index and the frequency of occurrence. n refers to the total number of user needs.

Through this calculation, the study determines the contribution of each design parameter to fulfilling the overall set of user needs, and accordingly ranks the functional priorities (as shown in Table 5), thereby providing a scientifically grounded basis for subsequent product concept development and resource allocation.

User requirement	**User requirement explained**	**Design function**
M1	Data Storage and Analysis	Encrypted Cloud Data Synchronization F1 AI-Based User Data Analysis F2 AI-Powered Automatic Classification of User Memorandum Events F3
O1	Focus Enhancement	Simplified Functionality for Reduced Distraction F4 Adaptive Task Prioritization System F5 Real-Time Biometric Monitoring for Cognitive State Tracking F6 Attention Focus Mechanism F7
O2	Daily Behavior Recording and Analysis	Automated Activity Classification F8 Gesture-Based Quick Note-Taking F9 AI-Generated Behavioral Analysis Insights F10
O3	Emotional and Stress Regulation	Stress Level Detection through Heart Rate Variability (HRV) Analysis F11 Intelligent Vibration Alerts for Relaxation Guidance F12

		AI-Guided Breathing Exercises F13
O4	Creative Work Enhancement	Real-Time Transcription of Voice Memos F14 Gesture-Triggered Creative Capture System F15 AI-Generated Creative Thinking Prompts F16
O5	Personal Efficiency Enhancement	Intelligent Task Reminder Notifications F17 Gesture-Based Integration of Schedules and To-Do Lists F18 Personalized Workflow Optimization Recommendations F19
O6	Wearable and Portable Features	Lightweight Ergonomic Design F20 Waterproof and Dustproof Material Application F21 Wireless Charging Support F22
A1	Mood Tracking	AI Emotion Analysis Based on Biometric Signals F23 Visualization of Personal Emotional History Trends F24 Context-Aware Notifications Based on Emotional State F25
A2	Relaxation Instruction	Meditation Guidance with Haptic Feedback F26 Relaxation Recommendations Based on Stress Levels F27
A3	ADHD Disease Diagnosis Function and Telemedicine Function	Continuous Cognitive Ability Tracking F28 ADHD Symptom Pattern Recognition F29 Telemedicine Consultation Report Generation F30
A4	Noise Control and Management	Adaptive Noise Reduction Alerts F31 Quiet Interaction Mode F32
A5	Context-Aware Feedback Function	Location-Based Interaction Suggestions F33 AI-Generated Time-Sensitive Reminders F34 Personalized Notifications Based on Behavioral Patterns F35
A6	Sensory Interaction Function	Gesture-Based Device Control F36 Customizable Haptic Feedback Patterns F37

Table 4.Transformation of user needs to design requirements



UR UF	Composite Weight	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	F33	F34	F35	F36	F37
M1	0.4898	◎	◎	◎			●		◎	◎	◎				●					△				●					◎	◎	◎							
O1	0.6471				◎	●		◎												◎												◎			●		△	
O2	0.549		●	◎			◎		◎	◎					△		◎												◎					◎				●
O3	0.6				◎						△	◎	◎	◎	●						△				●	◎		◎										
O4	0.549			●				◎		●	●					◎	◎																		◎			
O5	0.6531				●	◎	●	●		△							●	◎	◎	◎					△			△	●			●			△	◎		
O6	0.6458						△														△	◎	◎					△										◎
A1	0.54		△				△		◎			●			◎		●							◎	◎													
A2	0.549				△			●					◎	◎											△		◎	◎	●			●						
A3	0.5098								◎			●			◎		△		△	△				●						◎	△							
A4	0.5306			◎				△					△															●				◎	◎			●		
A5	0.5306									◎										●	△					◎	△					△		◎	△			
A6	0.551			△	△		●	●		●						△	◎			●								●									◎	◎
Total Score		2.449	4.636	10.045	9.2948	5.2068	6.143	11.377	10.443	10.664	6.757	6.1494	6.2756	5.745	12.345	6.845	11.2321	3.2655	3.7753	10.5011	1.7764	3.229	3.229	5.6988	5.7021	5.653	3.2756	10.2439	9.662	4.998	2.9588	10.0254	2.653	5.398	5.87	4.5873	3.4021	7.692

Table 5. House of Quality for design parameters in ADHD

4.4 Design element analysis based on QFD Methods

After the QFD mapping has been completed and the weighted scores for each design parameter have been obtained, these results still need to be further normalized and focused to avoid extreme value interference and overly subjective element selection. This study introduces Z-score normalization and Pareto analysis to normalize and stratify the importance levels of design elements based on their overall weighted scores. This approach enables an objective assessment of each design element's relative contribution within the overall system and facilitates the identification of the "vital few" factors. It thus provides decision-making support for the prioritization of functional modules and the optimal allocation of limited design resources.

Specifically, the study first applied Z-score normalization to the total weighted scores of 37 design elements. The calculation formula is as follows:

$$Z_j = \frac{W_j - \mu}{\partial}$$

Where W_j denotes the total weighted score of the j-th design feature, μ represents the mean of all feature scores, and ∂ refers to the standard deviation. According to the distribution of Z-values, features with $Z > 1$ are considered significantly above average in importance; those with $-1 < Z < 1$ fall within the moderate range; and features with $Z < -1$ are categorized as having relatively low importance.

Following this, a Pareto chart was constructed by ranking design features in descending order of their total weighted scores, overlaid with a cumulative percentage curve. According to the Pareto principle (80/20 rule), the features accounting for 80% of the cumulative score were identified as the top 20% high-weight features, referred to as the "critical few" design elements. Based on the results of the Z-score standardization and Pareto chart analysis (see Figure 4), the 37 design features were further categorized into three levels of priority to support functional selection and strategic planning in product development.

First, the Priority Design Features refer to those with Z-scores greater than 1, totaling seven features, which scored significantly higher than the average. These include F14 (12.345), F9

(11.7252), F7 (11.377), F16 (11.2321), F19 (10.5011), F8 (10.443), and F27 (10.2439). These features represent the core functional modules of the product system and are considered to have a critical impact on user satisfaction and system effectiveness. It is therefore recommended that these features be prioritized in product development and receive greater investment during prototyping and user testing phases for validation and optimization.

Second, the Secondary Design Features include those with Z-scores between –1 and 1, which fall into the mid-range of the statistical distribution. Although these features may not be of extreme significance, they hold potential value as supplementary functions to enhance user experience, particularly under diverse usage scenarios and individualized needs. For instance, features such as F3 (10.0708), F31 (10.0254), F2 (10.045), F28 (9.662), and F4 (9.2948) demonstrated moderate to high levels of importance and may be considered optional extensions in the system, depending on available project resources and user preferences.

Lastly, the Non-essential Design Features refer to those with Z-scores less than –1, indicating relatively low weight under the current user preference structure. These include F1 (2.449), F20 (1.7764), F30 (2.9588), as well as lower-ranking features such as F21 (3.229) and F22 (3.229). These features may be considered for elimination, integration, or postponement to future iterations, based on user feedback, so as to improve overall design efficiency and optimize resource allocation.

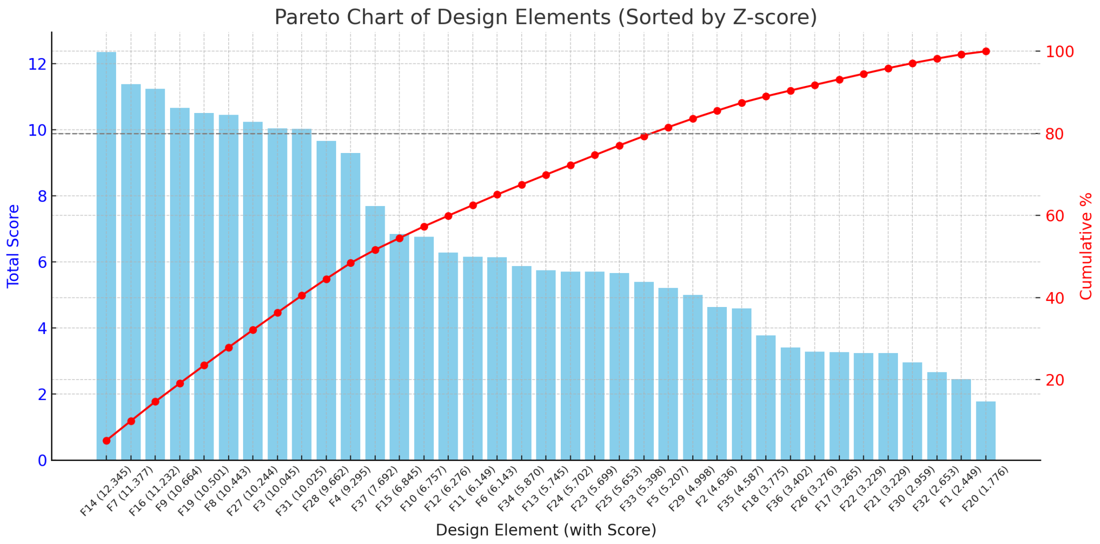


Figure 4. Pareto Chart of Design Element Weights

4.5 Design function guides conceptual design

After the high-priority functional elements have been accurately screened, how to integrate and transform these elements into a concrete product concept design becomes a key link to achieve the research objectives. In this section, we will focus on the first and second tier functional elements, propose compatibility combinations and scenario-based application strategies, and explore how to organically combine functional support with social integration needs through interaction innovation and modular design. More specifically, the first-level design features include functions such as real-time transcription of voice memos (F14), gesture-based quick note-taking (F9), attention focus mechanisms (F7), AI-generated creative thinking prompts (F16), personalized workflow optimization recommendations (F19), automated activity classification (F8), and relaxation recommendations based on stress levels (F27). These functions should be emphasized in the construction of design features, as they directly respond to the core needs of users with ADHD.

Taking F14 as an example, the voice memo transcription function can be combined with the functionality of F9 to form a gesture-triggered voice transcription system. Unlike conventional activation methods for memo-taking, this design leverages a simple gesture-based activation, which is more aligned with the divergent cognitive tendencies of ADHD users. The use of minimal and intuitive gestures reduces the cognitive load associated with complex feature navigation, offering a more accessible and seamless way for ADHD users to record fleeting thoughts. This can be particularly effective in capturing fragmented but important creative ideas and short-term memory content that are otherwise prone to being forgotten.

This approach aligns with the theoretical foundation of neurodiversity, a term first introduced by Australian sociologist Judy Singer and later popularized by American journalist Harvey Blume. The core idea of neurodiversity is to redefine conditions such as autism and ADHD not as pathologies but as natural variations in human neurology and cognition (Singer, 1998; Blume, 1998).

By incorporating the perspective of neurodiversity into the design process, this study refrains from treating individuals with ADHD as a uniform group of "patients." Instead, it adopts a sociological lens that acknowledges cognitive differences and seeks to support diverse neurological users through inclusive and tailored design strategies. This perspective is further supported by prior research, which has observed that individuals with ADHD and bipolar disorder often demonstrate higher levels of novelty-seeking and creative thinking compared to neurotypical controls (White & Shah, 2011; Simeonova et al., 2005). Such findings provide a rationale for using design to help ADHD users harness their creative strengths while compensating for their memory-related weaknesses.

In line with this understanding, we propose a simple and accessible gesture—a quick pinch between the thumb and index finger—as the activation trigger for voice memo transcription, as illustrated in Figure 5. This design reduces the number of steps required for recording, offering a cognitively lightweight and user-adaptive method for idea capture, particularly in moments of spontaneous creativity or task-switching.

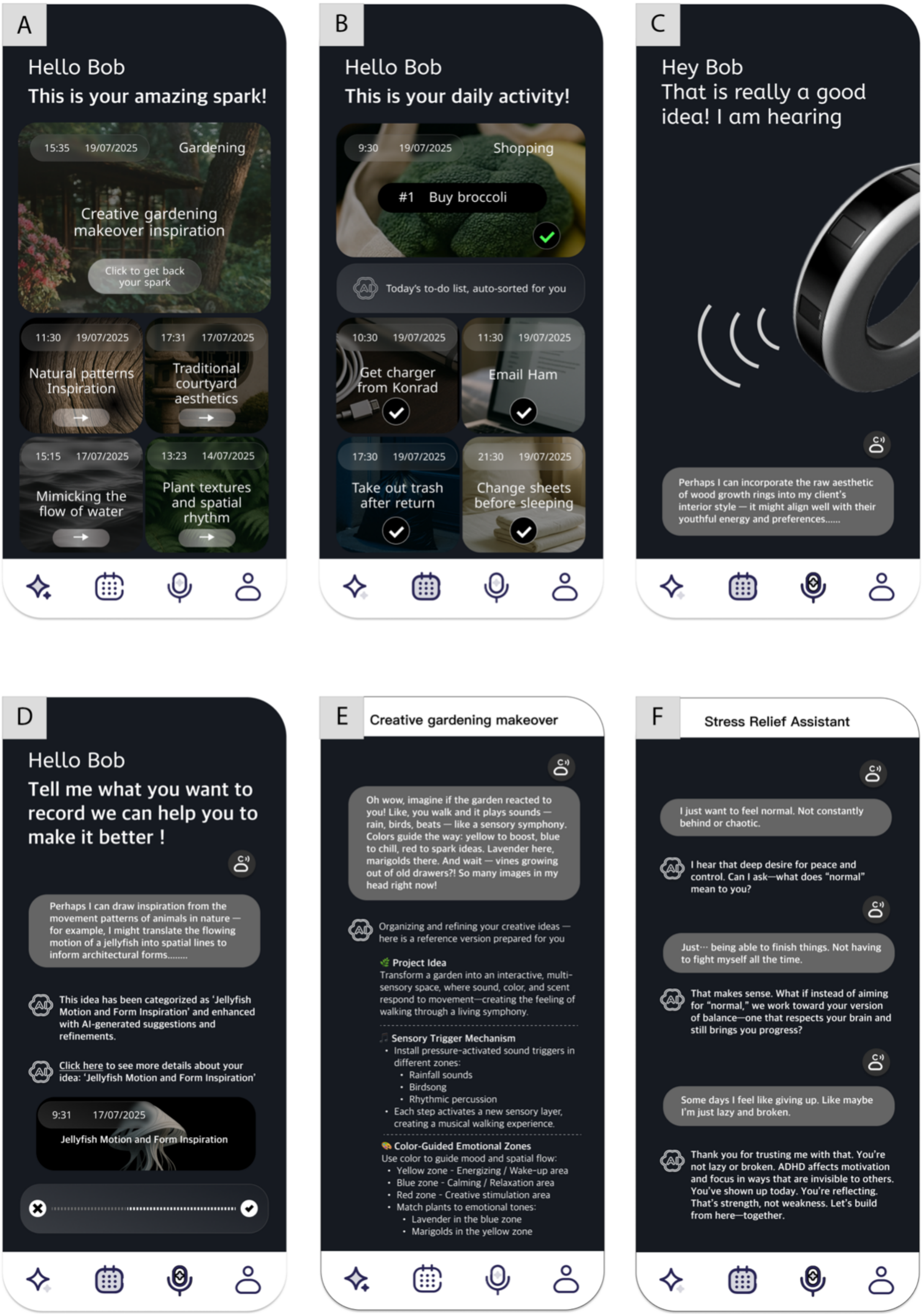
Figure 5. Smart Memo Capture through Gesture and Voice: A Functional Synthesis of F4 and F9

To extend the functionality described above, this study integrates three key features—F16 AI-Generated Creative Thinking Prompts, F19 Personalized Workflow Optimization Recommendations, and F8 Automated Activity Classification—into the design of an interconnected mobile application. Specifically, for the user need outlined in F16, the creative thinking prompt function is designed to follow the physical interaction point of F14 within the tangible device. After capturing the user's voice memo, the content is transcribed into text and transmitted to the connected mobile app. The app then leverages F8 automated activity classification function to categorize the transcribed information, thereby enabling F16 AI-based creative assistant.

This AI assistant operates by processing the transcribed voice data through an event classification model grounded in user behavior, as defined by F8. It then offers generative assistance tailored to the context of the memo. This process helps users, particularly those with ADHD, enrich and organize their captured content by aligning it with meaningful categories. The classification system is built around two major usage scenarios, defined according to the user's voice memo intentions and situational needs. The first scenario involves daily schedule recording (see Figure 6, part A), while the second focuses on capturing creative inspiration (see Figure 6, part B). The design of the AI creative assistant is articulated with respect to both of these scenarios.

In the first scenario, after the F8-based classification is complete, the user's events are sorted into categories related to everyday life activities. The AI assistant then helps refine the transcribed content, breaks down events into subcomponents, and offers suggestions for scheduling optimization. This design is also linked to the second-tier function F3, which concerns optimizing structured planning support. Together, these features aim to help individuals with ADHD better manage the complex and easily forgotten routines of daily life.

In the second scenario, the user utilizes the device to record creative thinking. Under this context, the AI assistant is designed to optimize the originally transcribed text and provide AI-driven expansion and refinement of the captured ideas (see Figure 6, parts C–E). Additionally, when users are engaged in multitasking situations, the assistant offers workflow optimization suggestions based on the structure and context of the recorded content. This feature corresponds to F19 Personalized Workflow Optimization Recommendations, facilitating users' later review and enhancing their ability to retrieve and interpret creative ideas more effectively.



Perhaps I can incorporate the raw aesthetic of wood growth rings into my client's interior style — it might align well with their youthful energy and preferences......

Perhaps I can draw inspiration from the movement patterns of animals in nature — for example, I might translate the flowing motion of a jellyfish into spatial lines to inform architectural forms........

This idea has been categorized as 'Jellyfish Motion and Form Inspiration' and enhanced with AI-generated suggestions and refinements.

Click here to see more details about your idea: 'Jellyfish Motion and Form Inspiration'

Oh wow, imagine if the garden reacted to you! Like, you walk and it plays sounds — rain, birds, beats — like a sensory symphony. Colors guide the way: yellow to boost, blue to chill, red to spark ideas. Lavender here, marigolds there. And wait — vines growing out of old drawers?! So many images in my head right now!

Organizing and refining your creative ideas — here is a reference version prepared for you

Project Idea
Transform a garden into an interactive, multi-sensory space, where sound, color, and scent respond to movement—creating the feeling of walking through a living symphony.

Sensory Trigger Mechanism
- Install pressure-activated sound triggers in different zones:
  - Rainfall sounds
  - Birdsong
  - Rhythmic percussion
- Each step activates a new sensory layer, creating a musical walking experience.

Color-Guided Emotional Zones
Use color to guide mood and spatial flow:
- Yellow zone - Energizing / Wake-up area
- Blue zone - Calming / Relaxation area
- Red zone - Creative stimulation area
- Match plants to emotional tones:
  - Lavender in the blue zone
  - Marigolds in the yellow zone

I just want to feel normal. Not constantly behind or chaotic.

I hear that deep desire for peace and control. Can I ask—what does "normal" mean to you?

Just··· being able to finish things. Not having to fight myself all the time.

That makes sense. What if instead of aiming for "normal," we work toward your version of balance—one that respects your brain and still brings you progress?

Some days I feel like giving up. Like maybe I'm just lazy and broken.

Thank you for trusting me with that. You're not lazy or broken. ADHD affects motivation and focus in ways that are invisible to others. You've shown up today. You're reflecting. That's strength, not weakness. Let's build from here—together.

Figure 6.Collaborative app design integrated with assistive devices for individuals with ADHD, including: (A) app interface for daily schedule tracking, (B) app interface for recording daily creative inspirations, (C、D、E) workflow diagrams illustrating the voice transcription, optimization, and creative expansion features across the wearable device and app system, and (F) visualization of the

virtual stress-relief assistant designed to support emotional regulation within the app.

For the functional transformation of user need F7 Attention Focus Mechanism, we draw on the concept of Fidget Widgets as proposed by Karlesky and Isbister in 2013. The authors observed that people often engage in unconscious bodily movements, such as playing with paper clips, tapping pens, doodling, or sliding a mouse, as a form of embodied cognition that can facilitate both creativity and attentional focus (Karlesky & Isbister, 2013). Existing research has also theorized that fidgeting may help modulate levels of concentration (Garger, 1990; Mason et al., 2007).

Building on these insights and the design focus of F7, we propose a ring-like wearable device that amplifies the natural gesture of rubbing the thumb and index finger—a common self-soothing behavior exhibited under anxiety. This motion is repurposed as a mechanism to relieve work-related stress and, simultaneously, to support attention focusing in users with ADHD. Specifically, in our design (as illustrated in Figure7), the user can rotate a black disc embedded in the center of the ring to perform this fidgeting action. This tactile interaction serves not only as an outlet for anxiety but also as a physical mechanism to enhance attentional control.

Figure 7. Enhancing User Focus through Hand-Based Fidget Widgets: A Functional Synthesis of F7

When users engage with this function over extended periods, particularly in high-stress situations, the relevance of feature F27 Relaxation Recommendations Based on Stress Levels becomes fully apparent. This functionality is integrated into the mobile application design, where an AI chatbot-based virtual stress-relief assistant provides support through conversational interaction. The assistant is designed to help individuals with ADHD alleviate stress by engaging in dialogue and offering tailored relaxation suggestions, as illustrated in Figure 6, part F.

For the second-tier design features, several elements were identified, including F3 AI-Powered Automatic Classification of User Memorandum Events, F31 Adaptive Noise Reduction Alerts, F2 AI-Based User Data Analysis , F28 Continuous Cognitive Ability Tracking, and F4 Simplified Functionality for Reduced Distraction. These features serve as important complements to the first-tier functions and are integrated accordingly to enhance the overall system experience.

For instance, the functionality of F3 has been deeply integrated with F8, enabling hierarchical classification of user daily events following the initial activity categorization. This helps users optimize their schedules and improve efficiency. The feature proposed in F31 has been embedded into the ring-based wearable device; when the surrounding environment becomes excessively noisy, the app will trigger an alert to inform the user that they are in a highly distracting environment, thereby supporting a smoother transition into a focused mental state.

The F2 functionality concerning user data analysis has been incorporated into the AI assistant within the app. The system analyzes user data to provide personalized insights, optimization strategies, and behavioral recommendations.

The emphasis on F4, which focuses on simplifying functionality to reduce distraction, is reflected in several aspects of the current design. First, the wearable physical device adopts a modular structure that minimizes the number of haptic alerts delivered to the user, thereby reducing the risk of sensory overload and attentional interference. Second, the app incorporates AI-powered automatic classification and content optimization mechanisms, which reduce the cognitive effort required for users to organize and interpret their recorded memos. This not only streamlines the interaction process but also mitigates the cognitive load typically associated with manual information processing. Third, the design aims to automate as many functions as possible while minimizing the necessity for explicit physical interactions. In particular, the wearable device is intentionally limited to two tangible interaction behaviors—gesture-based voice memo activation and fidget-oriented ring rotation—thereby significantly decreasing the likelihood of accidental input and lowering cognitive fatigue caused by complex interfaces.

As for the third-tier design elements—F1 Encrypted Cloud Data Synchronization, F20 Lightweight Ergonomic Design, F30 Telemedicine Consultation Report Generation, F21 Waterproof and Dustproof Material Application, and F22 Wireless Charging Support—these features are primarily considered post-conceptual development priorities, to be addressed in later stages of production and commercialization. Most of these elements concern material selection and manufacturing optimization, which lie beyond the scope of the current concept and testing phase.

Nonetheless, we acknowledge the long-term developmental potential of several third-tier features. In particular, F1, F20, F21, and F22 are viewed as critical for enhancing user satisfaction and product completeness, and they will be taken into deeper consideration in future development phases. Regarding F30, while this feature reflects an important medical need—namely, the difficulty many ADHD individuals face in accessing and defining psychiatric care—it is not included in the initial implementation scope of this assistive device-focused design due to the medical specialization required. However, the existence of such a feature further confirms the systemic challenge of healthcare accessibility among the ADHD population.

5 Conclusion

Our research integrates the Kano model's theory of hierarchical user needs with the systematic transformation framework of Quality Function Deployment (QFD), and innovatively introduces Z-score standardization and Pareto analysis. This methodological integration effectively addresses the subjectivity often found in traditional QFD approaches when determining the weights of design features, enabling a more systematic identification and transformation of the core needs of adults with ADHD. It achieves a synergy between qualitative insights (emotional user needs) and quantitative decision-making (technical prioritization).

At the theoretical level, this study proposes and establishes a neurodiversity-oriented methodological framework for assistive design targeting ADHD populations, thereby promoting a paradigm shift in academic discourse from “treatment and correction” toward “functional support and social integration.”

At the practical level, this research offers designers of medical assistive devices for individuals with ADHD a novel approach to identifying and analyzing user needs. The user insights derived from this study provide access to deep, hard-to-reach needs that are typically overlooked in conventional design processes. Through the development of conceptual design proposals, the study further expands the potential for design translation and deepens understanding of the non-clinical, experience-based needs of ADHD users—needs that have often remained underexplored in past practice.

Furthermore, this study establishes a neurodiversity-informed design paradigm centered on functional scaffolding rather than pathological correction. Traditional corrective interventions often attempt to “normalize” behavior by suppressing neurodivergent traits, such as attention dispersion and spontaneous motor activity, through punitive behavioral programs and environmental constraints (e.g., isolating users in low-stimulation environments or imposing rigid task compartmentalization). While these interventions may reduce surface-level symptoms in the short term, they tend to undermine intrinsic motivation, reinforce social stigma, and overlook the unique cognitive strengths of individuals with ADHD.

In contrast, our design framework reinterprets hallmark characteristics of ADHD, such as rapid associative thinking, heightened sensory responsiveness, and affinity for high-arousal environments, as design-enabling features. For example, the Unstress Spinning Module does not restrict physical activity but instead channels users' kinetic energy into a calming rotational experience that both soothes and stimulates creative ideation. Similarly, the Gesture-Triggered Idea Capture System leverages spontaneous physical movement to trigger real-time inspiration logging, transforming potential distractions into creative prompts. Rather than forcing ADHD users to conform to neurotypical standards, this approach is rooted in their lived experiences and cognitive profiles, fostering autonomy, empowerment, and genuinely participatory, human-centered design solutions. It also serves as a practical reference for inclusive design strategies and supports broader attention to neurodiversity in the design discipline.

The limitations of our research are primarily reflected in three aspects. First, the study focuses on ADHD individuals within a UK cultural context, resulting in limited geographic and cultural diversity among participants. Second, the participant group is primarily composed of students and their immediate stakeholders (e.g., parents and friends), leading to relatively narrow user representation. Third, the proposed design remains at the conceptual stage; it has not yet undergone empirical prototyping or testing, and its effectiveness in enhancing the real-world quality of life for ADHD users has yet to be validated.

Our future research can be improved in three key directions: first, by expanding the participant base to include more culturally and geographically diverse groups; second, by advancing the development of prototypes and conducting systematic usability testing; and third, by implementing longitudinal studies with participants to support iterative refinement and optimization of the proposed design solutions. In particular, future studies will focus on building fully functional prototypes and conducting user testing sessions to empirically validate the prioritized design features, ensuring their practical effectiveness and applicability in real-world ADHD user contexts.

References

Abaoud, A. A. (2022) An exploratory investigation of difficulties in applying functional behavior assessment and implementing behavioral intervention plans in ADHD programs in Saudi Arabia. *International Journal of Mental Health Promotion*, *24(2)*, 595–601. https://doi.org/10.32604/ijmhp.2022.021286

Abikoff, H., Gallagher, R., Wells, K. C., Murray, D. W., Huang, L., Lu, F., & Petkova, E. (2013). Remediating organizational functioning in children with ADHD: Immediate and long-term effects from a randomized controlled trial. *Journal of Consulting and Clinical Psychology*, *81(1)*, 113–128. https://doi.org/10.1037/a0029648

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders (5th ed.)*. American Psychiatric Publishing.

Arns, M., Heinrich, H., & Strehl, U. (2014). Evaluation of neurofeedback in ADHD: The long and winding road. *Biological Psychology*, *95*, 108–115. https://doi.org/10.1016/j.biopsycho.2013.11.013

Ayearst, L. E., Brancaccio, R. M., & Weiss, M. D. (2023). Improving on-task behavior in children and youth with ADHD: Wearable technology as a possible solution. *Journal of Pediatric Neuropsychology*, *9(2)*, 175–182. https://doi.org/10.1007/s40817-023-00152-6

Bakker, S., & Niemantsverdriet, K. (2016). The interaction-attention continuum: Considering various levels of human attention in interaction design. *International Journal of Design*, *10(2)*, 1–14.

Barkley, R. A. (1997). Behavioral inhibition, sustained attention, and executive functions: Constructing a unifying theory of ADHD. *Psychological Bulletin*, *121(1)*, 65–94. https://doi.org/10.1037/0033-2909.121.1.65

Basic, J., Uusimaa, J., & Salmi, J. (2024). Wearable motion sensors in the detection of ADHD: A critical review. In M. Särestöniemi et al. (Eds.), *Digital Health and Wireless Solutions (CCIS Vol. 2084)*. Springer. https://doi.org/10.1007/978-3-031-59091-7_12

Brown, A. J., & Casey, B. M. (2016). Subclinical ADHD symptoms are associated with executive functioning and externalizing problems in college students without ADHD diagnoses. *Journal of Educational and Developmental Psychology*, *6(1),* 204–219. https://doi.org/10.5539/jedp.v6n1p204

Chacko, A., Merrill, B. M., Kofler, M. J., & Fabiano, G. A. (2024). Improving the efficacy and effectiveness of evidence-based psychosocial interventions for ADHD in children and adolescents. *Translational Psychiatry,* 14, 244. https://www.nature.com/articles/s41398-024-02890-3

Cheng, D., Yang, Y., Yan, X., & Chen, Q. (2024). Improved effect of EEG-biofeedback intervention on cognitive function in childhood idiopathic epilepsy with ADHD: A retrospective study. *Heliyon*, *10(23)*, e040561. https://doi.org/10.1016/j.heliyon.2024.e040561

Cortese, S., Ferrin, M., Brandeis, D., et al. (2015). Cognitive training for attention-deficit/hyperactivity disorder: Meta-analysis of clinical and neuropsychological outcomes from randomized controlled trials. *Journal of the American Academy of Child & Adolescent Psychiatry, 54(3)*, 164-174. https://doi.org/10.1016/j.jaac.2014.12.010

Daley, D., Jones, K., Hutchings, J., & Thompson, M. (2009). Attention-deficit hyperactivity disorder in pre-school children: Current findings, recommended interventions and future directions. *Child: Care, Health and Development, 35(6)*, 763–782.. https://doi.org/10.1111/j.1365-2214.2009.00938.x

Dalsgaard, S., Østergaard, S. D., Leckman, J. F., Mortensen, P. B., & Pedersen, M. G. (2015). Mortality in children, adolescents, and adults with attention-deficit hyperactivity disorder: A nationwide cohort study. *The Lancet, 385(9983)*, 2190–2196. https://doi.org/10.1016/S0140-6736(14)61684-6

Doğan, N. Ö., & Akbal, H. (2020). Identification and evaluation of the ways of meeting patients' expectations from a hospital: An AHP-weighted QFD case study in a pediatric hospital. *Istanbul Business Research, 49(2)*, 224–247. https://doi.org/10.26650/ibr.2020.49.0070

Douglas, V. I. (1972). Hyperactive children: A review of research paradigms and theories. *Child Development, 43(2)*, 497–516. https://www.jstor.org/stable/1127932

Doulou, A., Pergantis, P., Drigas, A., & Skianis, C. (2025). Managing ADHD symptoms in children through the use of various technology-driven serious games: A systematic review. *Multimodal Technologies and Interaction, 9(1)*, 8. https://doi.org/10.3390/mti9010008

Drotar, D. (2009). Editorial: How to write effective reviews for the Journal of Pediatric Psychology. *Journal of Pediatric Psychology, 34(2)*, 113–117. https://doi.org/10.1093/jpepsy/jsn142

DuPaul, G. J., Evans, S. W., Cleminshaw-Mahan, C. L., & Fu, Q. (2024). School-based intervention for adolescents with ADHD: Predictors of effects on academic, behavioral, and social functioning. *Behavior Therapy, 55(4)*, 680–697. https://doi.org/10.1016/j.beth.2024.01.010

Faigel, H. C., Sznajderman, S., Tishby, O., Turel, M., & Pinus, U. (1995). Attention deficit disorder during adolescence – a review. *Journal of Adolescent Health, 16*, 174–184.

Faraone, S. V., Bellgrove, M. A., Brikell, I., et al. (2024). Attention-deficit/hyperactivity disorder. *Nature Reviews Disease Primers, 10(1)*, 11. https://doi.org/10.1038/s41572-024-00495-0

FARAONE, S. V., BIEDERMAN, J., & MICK, E. (2006). The age-dependent decline of attention deficit hyperactivity disorder: a meta-analysis of follow-up studies. *Psychological Medicine, 36(2)*, 159–165. doi:10.1017/S003329170500471X

Garger, S. (1990). Is there a link between learning style and neurophysiology? *Educational Leadership, 48(2)*, 63–65.

Gimpel, H., Manner-Romberg, T., Schmied, F. et al. Understanding the evaluation of mHealth app features based on a cross-country Kano analysis. *Electron Markets, 31*, 765–794 (2021). https://doi.org/10.1007/s12525-020-00455-y

Halperin, J. M., & Schulz, K. P. (2006). Revisiting the role of the prefrontal cortex in the pathophysiology of ADHD. *Psychological Bulletin, 132(4)*, 560–581. https://doi.org/10.1037/0033-2909.132.4.560

Hu, L.-F., Zhang, Y., Li, W., et al. (2025). White matter microstructural subgroups of children with ADHD: Similar clinical presentations and distinct neuropsychological profiles. *Journal of Psychiatric Research, 183,* 197–203. https://doi.org/10.1016/j.jpsychires.2025.02.028

Jin, Y. (2023). Office space design based on Kano Model, AHP, QFD methods. *In Proceedings of IASDR* 2023.

Kanemura, H., Sano, F., Tando, T., Hosaka, H., Sugita, K., & Aihara, M. (2013). EEG improvements with antiepileptic drug treatment correlate with behavioral recovery in children with ADHD. *Epilepsy & Behavior, 27(3),* 443–448. https://doi.org/10.1016/j.yebeh.2013.03.014

Kano, N., Seraku, N., Takahashi, F., & Tsuji, S. (1984). Attractive quality and must-be quality. *Journal of the Japanese Society for Quality Control, 14(2),* 147–156. https://doi.org/10.20684/quality.14.2_147

Karlesky, M., & Isbister, K. (2013). Fidget widgets: Secondary playful interactions in support of primary serious tasks. CHI EA '13: CHI '13 Extended Abstracts on Human Factors in Computing Systems, 1149–1154. https://doi.org/10.1145/2468356.2468561

Kennedy, T. M., Molina, B. S. G., & Pedersen, S. L. (2022). Change in Adolescents' Perceived ADHD

Symptoms Across 17 Days of Ecological Momentary Assessment. *Journal of Clinical Child & Adolescent Psychology, 53(3)*, 397–412. https://doi.org/10.1080/15374416.2022.2096043

Klingberg, T., Fernell, E., Olesen, P. J., et al. (2005). Computerized training of working memory in children with ADHD—A randomized, controlled trial. *Journal of the American Academy of Child & Adolescent Psychiatry, 44(2)*, 177-186. https://doi.org/10.1097/00004583-200502000-00010

Klingberg, T., Forssberg, H., & Westerberg, H. (2002). Training of working memory in children with ADHD. *Journal of Clinical and Experimental Neuropsychology, 24(6)*, 781–791. https://doi.org/10.1076/jcen.24.6.781.8395

Kollins, S. H., DeLoss, D. J., Cañadas, E., et al. (2020). A novel digital intervention for actively reducing severity of paediatric ADHD (STARS-ADHD): A randomised controlled trial. *The Lancet Digital Health, 2(4)*, e168–e178. https://doi.org/10.1016/S2589-7500(20)30017-0

Kollins, S. H., Childress, A., Heusser, A. C., et al. (2021). Effectiveness of a digital therapeutic as adjunct to medication in pediatric ADHD. *npj Digital Medicine, 4,* 58. https://doi.org/10.1038/s41746-021-00429-0

Kurokawa, S., Nomura, K., Hosogane, N., et al. (2024). Reliability of telepsychiatry assessments using the ADHD Rating Scale-IV for children with neurodevelopmental disorders and their caregivers: Randomized feasibility study. *Journal of Medical Internet Research, 26*, e51749. https://doi.org/10.2196/51749

Koutsabasis, P., Vogiatzidakis, P., & Darzentas, J. (2021). Minimalist design principles for ADHD-focused interfaces: A case study of time management tools. *Universal Access in the Information Society, 20(3)*, 441-456. https://doi.org/10.1007/s10209-020-00776-9

Lange, K. W., Reichl, S., Lange, K. M., & Tucha, O. (2010). The history of attention-deficit hyperactivity disorder. *ADHD Attention Deficit and Hyperactivity Disorders, 2(4)*, 241–255. https://doi.org/10.1007/s12402-010-0045-8

Lavigne, J. V., Gibbons, R. D., Christoffel, K. K., et al. (1996). Prevalence rates and correlates of psychiatric disorders among preschool children. *Journal of the American Academy of Child & Adolescent Psychiatry, 35*, 204–214.

Lee, Y.-C., Chen, C.-R., & Lin, K.-C. (2022). Effects of mindfulness-based interventions in children and adolescents with ADHD: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health, 19(22)*, 15198. https://doi.org/10.3390/ijerph192215198

Lyu, J., Chen, R., Yang, L., Wang, J., & Chen, M. (2022). Applying a hybrid Kano/QFD integration approach to wood desk designs for open-plan offices. *Forests, 13(11)*, 1825. https://doi.org/10.3390/f13111825

Marentakis, G., Borthakur, D., Batchelor, P., Andersen, J. P., & Grace, V. (2021). Using breath-like cues for guided breathing. *In CHI EA '21 (Art. 468, pp. 1-7)*. ACM. https://doi.org/10.1145/3411763.3451796

Mason, M. F., Norton, M. I., Van Horn, J. D., et al. (2007). Wandering minds: The default network and stimulus-independent thought. *Science, 315(5810)*, 393–395.

Maurizio, S., Wahl, S., Treder, M. S., et al. (2014). Comparing tomographic EEG neurofeedback and EMG biofeedback in children with ADHD. *Biological Psychology, 95*, 31–44. https://doi.org/10.1016/j.biopsycho.2013.10.008

Merrill, B. M., Thompson, M. J., Chacko, A., et al. (2024). Diversity and representation in ADHD psychosocial treatment research: A comprehensive synthesis. *Clinical Psychology Review, 112,* 102461. https://doi.org/10.1016/j.cpr.2024.102461

Montesinos González, S., Vázquez Cid de León, C., & Ramírez Castillo, E. A. (2023). Continuous improvement of a face protection mask using quality function deployment. Revista Venezolana de Gerencia, 28(Edición Especial 10), 1280–1297. https://doi.org/10.52080/rvg.28.e10.25

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2016). Just-in-time adaptive interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. Annals of Behavioral Medicine, 52(6), 446–462. https://doi.org/10.1007/s12160-016-9830-8

Neira-Rodado, D., Ortíz-Barrios, M., De la Hoz-Escorcia, S., et al. (2020). Smart product design through a fuzzy Kano-AHP-DEMATEL-QFD approach. *Applied Sciences, 10(5)*, 1792. https://doi.org/10.3390/app10051792

Neudecker, C., Mewes, N., Reimers, A. K., & Woll, A. (2015). Exercise interventions in children and adolescents with ADHD: A systematic review. *Journal of Attention Disorders, 23(4)*, 307–324. https://doi.org/10.1177/1087054715584053

Păsărelu, C. R., Andersson, G., & Dobrean, A. (2020). Attention-deficit/hyperactivity disorder mobile apps: A systematic review. *International Journal of Medical Informatics, 138*, 104133. https://doi.org/10.1016/j.ijmedinf.2020.104133

Pfeiffer, B., Henry, A., Miller, S., & Witherell, S. (2008). Effectiveness of disc “wiggle” seats on attention in first-grade children with ADHD. *American Journal of Occupational Therapy, 62(3)*, 274–281. https://doi.org/10.5014/ajot.62.3.274

Polanczyk, G., de Lima, M. S., Horta, B. L., Biederman, J., & Rohde, L. A. (2007). The worldwide prevalence of ADHD: A systematic review and meta-regression analysis. *American Journal of Psychiatry, 164(6)*, 942–948. https://doi.org/10.1176/ajp.2007.164.6.942

R de Graaf, R., Kessler, R. C., Fayyad, J., & ten Have, M. L. (2008). The prevalence and effects of adult ADHD on the performance of workers: Results from the WHO World Mental Health Survey Initiative. *Occupational and Env*ironmental Medicine, 65(12), 835–842. https://doi.org/ 10.1016/j.yebeh.2013.03.014

Ros-Demarize, R., & Graziano, P. A. (2017). Social functioning in children with or at risk for attention deficit/hyperactivity disorder: A meta-analytic review. Journal of Clinical Child & Adolescent Psychology, 46(6), 762–777. https://doi.org/10.1080/15374416.2016.1266644

Söderlund, G. B., Sikström, S., & Smart, A. (2007). Listen to the noise: Noise is beneficial for cognitive performance in ADHD. *Journal of Child Psychology and Psychiatry, 48(8)*, 840–847. https://doi.org/10.1111/j.1469-7610.2007.01749.x

Shaw, P., Stringaris, A., Nigg, J., & Leibenluft, E. (2014). Emotion dysregulation in ADHD. *American Journal of Psychiatry, 171(3),* 276–293. https://doi.org/10.1176/appi.ajp.2013.13070966

Simeonova, D. I., Chang, K. D., Strong, C., & Ketter, T. A. (2005). Creativity in familial bipolar disorder. *Journal of Psychiatric Research, 39(6)*, 623–631.

Solanto, M. V., Marks, D. J., Mitchell, K. J., Wasserstein, J., & Kofman, M. D. (2010). Efficacy of meta-cognitive therapy for adult ADHD. *American Journal of Psychiatry, 167(8),* 958–968. https://doi.org/10.1176/appi.ajp.2010.09081107

Sonne, T., & Jensen, M. M. (2016). ChillFish: A respiration game for children with ADHD. *In TEI ’16* (pp. 271-278). ACM. https://doi.org/10.1145/2839462.2839480

Sonne, T., Müller, J., & Obel, C. (2016). Designing real-time assistive technologies for ADHD. *In CHI ’16* (pp. 1456-1466). ACM. https://doi.org/10.1145/2858036.2858041

Spiel, K., Hornecker, E., Williams, R. M., & Good, J. (2022). ADHD and technology research—Investigated by neurodivergent readers. *In CHI '22* (Art. 547, pp. 1-21). ACM. https://doi.org/10.1145/3491102.3517592

Stefanidi, E., Schöning, J., Feger, S. S., et al. (2022). Designing for care ecosystems: A literature review of technologies for children with ADHD. *In IDC '22* (pp. 13-25). ACM. https://doi.org/10.1145/3501712.3529746

Sujiono, F., & Krisnawati, F. (2025). Analysis of after-sales service quality for hotel smart lock products using the Servqual method and Quality Function Deployment (QFD). Syntax Literate: Jurnal Ilmiah Indonesia, 10(9), 7996–8013.

Tse, Y. J., Vander Stoep, A., McCarty, C., & Myers, K. (2015). Teletherapy delivery of caregiver behavior training for children with attention-deficit hyperactivity disorder. Telemedicine and e-Health, 21(6), 451–458. https://doi.org/10.1089/tmj.2014.0132

Van de Weijer-Bergsma, E., Formsma, A. R., de Bruin, E. I., & Bögels, S. M. (2012). The effectiveness of mindfulness training on behavioural problems and attentional functioning in adolescents with ADHD. *Journal of Child and Family Studies, 21(5),* 775-787. https://doi.org/10.1007/s10826-011-9531-7

Verduyn, P., Schulte-Strathaus, J. C. C., Kross, E., & Hülsheger, U. R. (2021). When do smartphones displace face-to-face interactions and what to do about it? *Computers in Human Behavior, 114,* 106550. https://doi.org/10.1016/j.chb.2020.106550

Volkow, N. D., Wang, G. J., Newcorn, J., et al. (2007). Depressed dopamine activity in caudate and preliminary evidence of limbic involvement in adults with ADHD. *Archives of General Psychiatry, 64(8)*, 932-940. https://doi.org/10.1001/archpsyc.64.8.932

Vysniauske, R., Verburgh, L., Oosterlaan, J., & Molendijk, M. L. (2016). The effects of physical exercise on functional outcomes in the treatment of ADHD: A meta-analysis. *Journal of Attention Disorders, 24(5)*, 644-654. https://doi.org/10.1177/1087054715627489

Ware, S., Knouse, L. E., Draz, I., & Enikeeva, A. (2023). Predicting ADHD symptoms using smartphone sensing data. *In UbiComp/ISWC '22 Adjunct* (pp. 503-505). ACM. https://doi.org/10.1145/3544793.3563430

Weerdmeester, J., Cima, M., Granic, I., Hashemian, Y., & Gotsis, M. (2016). A feasibility study on the effectiveness of a full-body videogame intervention for decreasing ADHD symptoms. *Games for Health Journal, 5(4).* https://doi.org/10.1089/g4h.2015.0103

Weisberg, D. S., Kirsner, K., Xu, J., & Michaels, C. R. (2014). TangiPlan: A tangible interface for supporting morning routines in children with ADHD. *In CHI '14* (pp. 3503-3512). https://doi.org/10.1145/2556288.2557131

Weisberg, O., Gal-Oz, A., Berkowitz, R., et al. (2014). TangiPlan: Designing an assistive technology to enhance executive functioning among children with ADHD. *In IDC '14* (pp. 293-296). ACM. https://doi.org/10.1145/2593968.2610475

Wheeler, J., & Carlson, C. L. (1994). The social functioning of children with ADD with hyperactivity and ADD without hyperactivity: A comparison of their peer relations and social deficits. *Journal of Emotional and Behavioral Disorders, 2(1),* 2-12. https://doi.org/10.1177/106342669400200101

White, H. A., & Shah, P. (2006). Uninhibited imaginations: Creativity in adults with ADHD. *Personality and Individual Differences, 40(6),* 1121-1131. https://doi.org/10.1016/j.paid.2005.11.007

White, H. A., & Shah, P. (2011). Creative style and achievement in adults with ADHD. *Personality and Individual Differences, 50(5),* 673-677.

Willig, C., & Wirth, L. (2018). A meta-synthesis of studies of patients' experience of living with terminal cancer. *Health Psychology, 37(3),* 228-237. https://doi.org/10.1037/hea0000581

Wolraich, M. L., Hagan, J. F., Allan, C., et al. (2019). Clinical practice guideline for the diagnosis, evaluation, and treatment of ADHD in children and adolescents. *Pediatrics, 144(4)*, e20192528. https://doi.org/10.1542/peds.2019-2528

Zhu, Q., Nguyen, D. T., Alyea, G., Hanson, K., Sid, E., & Pariser, A. (2020). Phenotypically similar rare-disease identification from an integrative knowledge graph: Preliminary study. *JMIR Medical Informatics, 8(10)*, e18395. https://doi.org/10.2196/18395

Zentall, S. S., & Shaw, J. H. (1980). Effects of classroom noise on performance and activity of second-grade hyperactive and control children. *Journal of Educational Psychology, 72(6)*, 830-840. https://doi.org/10.1037/0022-0663.72.6.830

Grady, J. S., Her, M., Moreno, G., Perez, C., & Yelinek, J. (2019). Emotions in storybooks: A comparison of storybooks that represent ethnic and racial groups in the United States. *Psychology of Popular Media Culture, 8(3),* 207–217. https://doi.org/10.1037/ppm0000185

About the Authors:

Zixiang Feng: Research focuses on HCI design and user behavior research. Specializing in human factors studies.

Yiwei Mo : Research focuses on interaction design, emphasizing quantitative methods to address design research challenges.

Zhaochuan Fang : Specializing in sustainability, soundscape, and visual arts; finalist at Adobe APA Design Awards; UN Design for Good certified; experienced in branding and public campaigns promoting social and environmental impact.

Wenjinhan Chen: A designer focused on critical research and ecological cycles, with a particular interest in biomaterials and biodegradable dye research

Acknowledgement: This research was supported by the China Undergraduate Innovation Training Program (Project No. S202510523007) and the HIFA Art Innovation Center of Hubei Institute of Fine Arts.