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ORIGINAL ARTICLE

Designing for Diversity: A Human Factors Perspective on the 'People' Dimension of the PACT Framework in Interactive Systems

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ABSTRACT

This study examines the influence of user diversity on the design and effectiveness of interactive systems, with particular emphasis on the "People" component of the PACT (People, Activities, Contexts, Technologies) framework. As digital technologies become more embedded in everyday life, designing for variability in users' physical, cognitive, and social characteristics has emerged as a central concern in human factors and ergonomics. Through a systematic review of over 15 peer-reviewed studies, this research identifies how differences in mobility, dexterity, and sensory capabilities impact interactions with modalities such as touch interfaces, 3D input devices, and motion-based controls. Psychological traits, including anxiety, resistance to change, and perceived social isolation, also surfaced as critical factors shaping user engagement and satisfaction, particularly in AI-enhanced environments. Social influences, including cultural background, group dynamics, and demographic variables, further mediate interaction patterns and acceptance of technology. These findings emphasize the need for inclusive, adaptive interface designs that can respond to a wide range of user profiles. By synthesizing insights across human physical, psychological, and social dimensions, the study contributes to a deeper understanding of inclusive design in HCI. It offers evidence-based design recommendations that support the development of systems that are not only functional and accessible, but also contextually sensitive and emotionally attuned. The implications aim to guide designers and developers in creating interactive technologies that enhance usability, equity, and user satisfaction across diverse populations.

Keywords: User-Centered Design, Inclusive Design, Human-Computer Interaction, Adaptive Interfaces, PACT Framework

INTRODUCTION

In the digital era, interactive systems have become indispensable across personal, professional, and social domains. From mobile applications to virtual collaboration tools, these systems mediate how individuals communicate, work, and engage with their environments. As technological capabilities evolve, so too does the imperative to design systems that are inclusive, adaptive, and responsive to the diverse characteristics of their users. Despite notable progress in interface design and accessibility, many systems still fall short in addressing the full spectrum of user diversity, particularly in terms of physical, psychological, and social variation (Wobbrock et al., 2011; Al-Khalifa et al., 2021). This gap can lead to usability issues, disengagement, and in some cases, the unintentional exclusion of certain user groups (Lazar et al., 2017). The PACT framework, comprising People, Activities, Contexts, and Technologies, offers a structured approach to analyzing and designing interactive systems (Benyon, 2019). Central to this framework is the "People" element, which represents the most dynamic and variable component of any system. Unlike technology or content, which can be systematically developed and standardized, the human dimension is inherently complex and multifaceted.

This research undertakes a systematic literature review that explore how user variability, across physical, psychological, and social dimensions, affects interaction with digital systems. The review identifies recurring challenges in design, such as limited accessibility, low cultural adaptability, and insufficient personalization, while also highlighting successful strategies and best practices (Shi et al., 2021). The objective is to derive actionable insights that support the development of interactive systems grounded in user-centered principles. The decision to focus on the "People" element is rooted in the understanding that the ultimate success of any system is measured by how effectively it supports and resonates with its users. While technology and content are integral, it is the human-system interaction that defines usability, satisfaction, and long-term adoption (Norman, 2013). By prioritizing the diverse needs and experiences of users, this research contributes to advancing inclusive design practices that align with human factors and ergonomics principles. The insights generated aim to guide designers and practitioners in building interactive systems that are not only technically robust, but also accessible, meaningful, and inclusive.

METHODOLOGY

Understanding how physical, psychological, and social differences influence user interaction with digital systems requires a robust and multi-faceted methodological approach. This study adopts a systematic reviews, provide a structured method for synthesizing research findings across diverse studies, identifying trends, gaps, and design implications. Figure 1 shows the overlapping factors used as the keywords.

In the domain of interactive system design, recognizing the diverse needs and characteristics of users is fundamental to achieving usability, accessibility, and inclusivity. This review draws on interdisciplinary literature to examine how physical, psychological, and social differences shape user interaction and influence system performance. Synthesizing these studies provides critical insights into how adaptive, user-centered design can address both functional and contextual user needs.

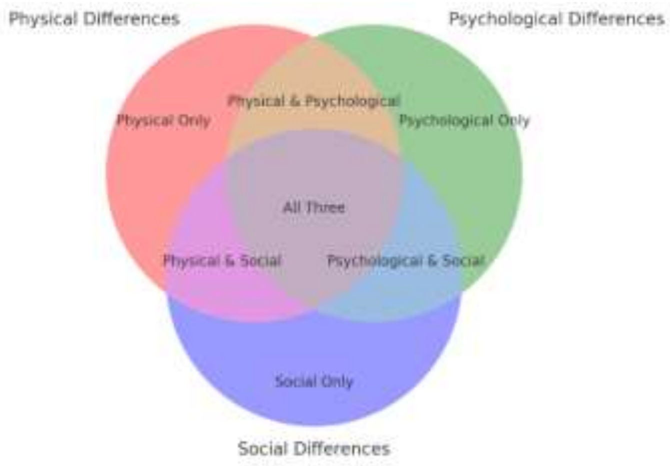

Figure 1: Overlapping Factors in Physical, Psychological, and Social Differences

Physical Differences

Physical variability among users, particularly in mobility, sensory perception, and motor control, profoundly influences how individuals engage with interactive technologies. This dimension is especially relevant in systems involving gesture-based, motion-based, or spatial interactions. Research in augmented reality (AR) systems shows that physical ability significantly impacts task performance. For example, Marques et al. (2022) demonstrated that users with limited mobility face challenges performing assembly tasks in AR environments due to constraints in manipulating virtual objects. Their findings stress the need for customizable interaction techniques to support a broader user base. Similarly, Mendes et al. (2020) explored how blind users engage with collaborative tabletops. Their work showed that auditory feedback can effectively replace visual cues, enhancing the usability of shared interfaces for users with visual impairments. This highlights the potential of multimodal feedback to support inclusive collaboration. Azofeifa et al. (2022) emphasized the growing role of multimodal HCI, including haptics, virtual reality, and motion interfaces, in compensating for physical impairments. Langdon et al. (2000) further illustrated how haptic feedback mechanisms could improve tactile interaction for users with limited motor function, improving both precision and user satisfaction. Moreover, adaptive interfaces that respond to individual physical preferences have shown promise in enhancing usability. Miraz et al. (2021) advocated for systems that dynamically adjust interaction modes based on user abilities, ensuring that interfaces remain usable regardless of physical variation.

Table 1. Comparison of Interaction Methods Based on Physical Abilities

Interaction Method	Effective for Users with Mobility Impairments	Effective for Users with Fine Motor Skill Impairments	Comments
Touch Gestures	Moderate	Challenging	May require customization for precision tasks
3D Controllers	Effective	Moderate	Offers more control but may require fine-tuning
Mobile Device Movements	Moderate	Challenging	Heavily dependent on device size, grip, and ergonomics

Table 1 illustrates the differing effectiveness of common interaction methods for users with physical impairments. These differences underscore the importance of customizable, multimodal input strategies to support diverse user groups.

Psychological Differences

Psychological traits, such as loneliness, anxiety, resistance to innovation, and cognitive flexibility, also influence how users interact with digital systems, particularly AI-driven platforms. Liu et al. (2023) investigated how psychological factors affect perceptions of AI voice assistants. Their findings revealed that loneliness increases usage frequency but does not guarantee satisfaction, while users with high resistance to innovation tend to avoid advanced features unless presented in a familiar context. Hu (2023) explored how interactive system design could either trigger or alleviate user anxiety, recommending emotionally supportive UI elements to enhance comfort and trust. Likewise, Attig et al. (2017) reviewed how personality traits, such as playfulness, innovativeness, and computer self-efficacy, predict engagement levels in digital environments, suggesting the value of tailoring systems based on user profiles. Cockburn et al. (2017) further examined how interaction sequencing influences user cognition and satisfaction. Their results suggest that poorly structured interactions elevate cognitive load, while clear, progressive flows promote ease-of-use and confidence. In VR environments, Lee et al. (2024) highlighted the psychological importance of task accuracy, completion time, and user comfort, recommending system designs that dynamically adapt based on cognitive or emotional state.

Table 2. Psychological Traits Impacting AI Voice Assistant Interaction

Psychological Trait	Impact on User Interaction	Suggested Design Adaptations
Loneliness	High engagement; lower emotional satisfaction	Personalized prompts; companionship-style interactions
Resistance to Innovation	Avoidance of advanced features; low initial uptake	Gradual introduction; use of familiar metaphors and onboarding elements
Privacy Concerns	Limited trust; reduced feature exploration	Transparent policies; granular privacy settings

Table 2 highlights how psychological diversity affects AI system interaction, offering concrete adaptations to enhance user trust and engagement.

Social Differences

Social context, including cultural background, group dynamics, and demographic diversity, significantly shapes how users interpret and engage with technology. Oh and Sundar (2016) analyzed user behavior in interactive media environments, showing that social context, including peer behavior and demographic alignment, affects engagement duration and feedback styles. In the context of digital video platforms, Wei (2022) examined barrage systems (real-time comment overlays), revealing that fluctuations in social interaction density alter user participation and attention. Research by van Erp and Toet (2015) on social touch technologies demonstrated how simulated touch can increase user trust and emotional connection in human-agent interactions. Their study supports the incorporation of social cues in system interfaces to enhance user rapport. Jha and Verma (2023) examined how users across different platforms engage with content depending on their social ecosystem, suggesting platform-specific adaptations to foster community and retention. Additionally, Kostakos et al. (2005) investigated how emerging technologies influence social behavior, calling for design approaches that are sensitive to evolving norms and interactions in both public and private contexts. This visualization in Figure 2 reflects the role of demographic and cultural factors in shaping user interaction patterns. Such insights are vital in designing context-aware social platforms that support engagement across different communities.

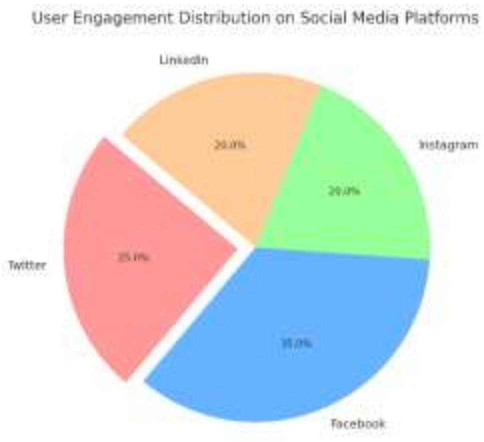

Figure 2: User Engagement Distribution on Social Media Platforms

RESULTS

The synthesis of literature across multiple studies provides a nuanced understanding of how physical, psychological, and social differences shape user interaction with interactive systems. The findings emphasize the importance of adaptive design practices that accommodate the diverse needs of users and contribute to the development of inclusive technologies. This section presents the key findings across the three dimensions, highlighting usability challenges, opportunities for inclusive design, and the implications for human-centered development.

Physical Differences

Studies examining physical differences revealed that interaction modalities can significantly affect usability and satisfaction for users with diverse physical abilities. Marques et al. (2022) found that in AR-based assembly tasks, users with mobility impairments preferred 3D controllers due to their ergonomic advantages and reduced physical demand. Conversely, users with fine motor skill impairments experienced difficulty using touch gestures, indicating that certain interaction methods require a high degree of precision and may not be universally accessible. In the context of visual impairments, Mendes et al. (2020) demonstrated that auditory feedback significantly enhanced performance and task completion rates for blind users interacting with collaborative tabletops. This reinforces the value of multisensory feedback mechanisms to support accessibility. The systematic review by Azofeifa et al. (2022) supported these findings by highlighting how multimodal interaction technologies, including haptics and virtual reality, can be adapted to users' physical capabilities, providing richer and more accessible digital experiences. Langdon et al. (2000) further confirmed that haptic feedback enhances interface usability for individuals with motor impairments by providing clear tactile cues. Lastly, Miraz et al. (2021) emphasized the role of adaptive user interfaces in improving both task performance and user satisfaction. Interfaces that dynamically adjust to physical user needs can increase inclusion and reduce frustration, particularly for those with functional limitations.

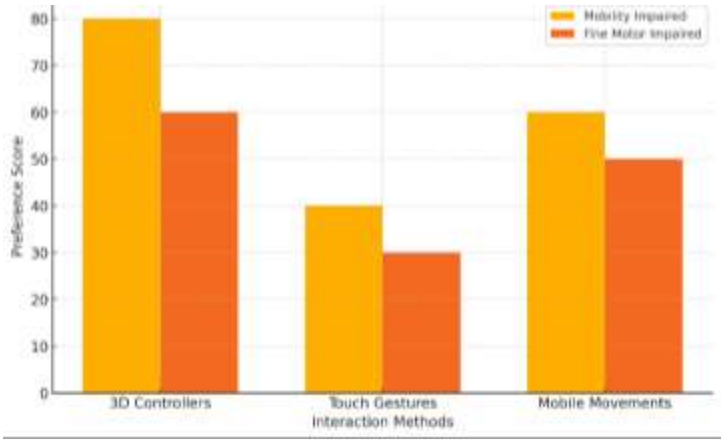

Figure 3: User Preferences Across Interaction Methods in AR Systems

Psychological Differences

Psychological traits and states play a substantial role in shaping user interaction outcomes. Liu et al. (2023) reported that users experiencing loneliness or resistance to innovation perceived less satisfaction and value when interacting with AI voice assistants. These traits influenced the frequency of use and depth of engagement, suggesting a need for emotionally intelligent and adaptive AI interfaces. Hu (2023) examined how system complexity influences psychological well-being. The study found that users experiencing cognitive overload were more likely to report anxiety, while intuitive interfaces that provided clear feedback helped mitigate stress and improve engagement. Attig et al. (2017) assessed the role of personality traits such as computer self-efficacy and playfulness in shaping technology adoption. Individuals with higher self-efficacy engaged more confidently with new systems, while playful users found greater enjoyment in exploration-based interactions. Cockburn et al. (2017) demonstrated that interaction sequencing significantly affects cognitive load. When tasks were presented in a logically progressive order, users reported increased satisfaction and reduced cognitive effort. Lee et al. (2024) extended this work to VR environments, revealing that task accuracy and completion times were positively correlated with psychological comfort. This indicates that emotionally supportive design strategies can directly influence performance in immersive systems.

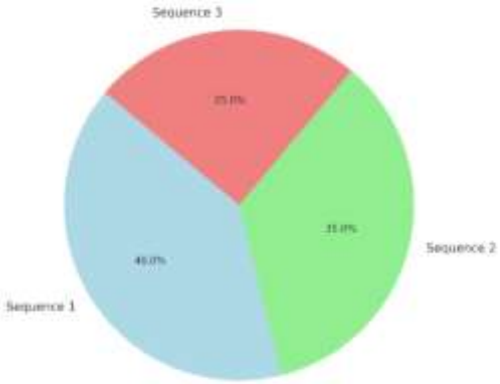

Figure 4: User Satisfaction by Interaction Sequencing

Social Differences

Social and cultural factors also contribute significantly to user behavior in interactive environments. Oh and Sundar (2016) found that demographic background and cultural context influenced how users engaged with media platforms. Differences in engagement levels suggest that interface design must account for varying expectations and social norms. Wei (2022) examined barrage systems in digital video platforms and observed that while real-time comment features enhanced immediate engagement, excessive barrage could overwhelm users and discourage sustained interaction. This highlights the importance of balancing real-time and asynchronous communication features to support varying social preferences. The role of social touch in HCI was explored by van Erp and Toet (2015), who found that touch-enabled social agents improved user perceptions of trust and connection, particularly in socially driven tasks. The incorporation of human-like social cues enhanced emotional resonance and interaction quality. Jha and Verma (2023) explored user behavior across social media platforms, identifying that platform-specific engagement patterns are shaped by user demographics and content type. Their findings underscore the need for context-sensitive design strategies to maximize engagement and accessibility. Kostakos et al. (2005) emphasized that emerging technologies must be designed with awareness of their social implications, noting that systems perceived as intrusive or insensitive to social context risk alienating users. Technologies that support natural, inclusive social interaction were found to be more widely adopted and trusted.

DISCUSSION

This section synthesizes findings from studies on physical, psychological, and social user differences, offering an integrative perspective on how these dimensions affect interaction with digital systems. The implications of these findings underscore the necessity of user-centered, inclusive, and adaptive design principles that recognize and accommodate the diverse needs of technology users. By mapping research insights to real-world design strategies, this discussion advocates for a paradigm shift toward customizable interfaces, emotionally intelligent systems, and culturally adaptive platforms.

Physical Differences

Studies on physical variation reveal critical insights for interaction design, particularly in systems that rely on gesture-based, spatial, or tactile modalities. Marques et al. (2022) concluded that while AR platforms offer enhanced engagement and task immersion, their effectiveness is limited if interaction methods are not adaptable to user mobility or dexterity levels. The broader implication is clear: interaction paradigms must support multi-modal inputs, such as voice commands, eye-tracking, or switch-based control, to ensure equitable access. Mendes et al. (2020) extended this insight by showing how auditory cues enhanced participation and accuracy for blind users engaging with collaborative tabletop interfaces. These findings reinforce the value of multisensory design in compensating for sensory or motor impairments. Moreover, the integration of haptics and VR (Azofeifa et al., 2022; Langdon et al., 2000) demonstrated how tactile responses can improve spatial orientation, reduce error rates, and increase user confidence. The adoption of adaptive interfaces that respond to user input and adjust in real time (Miraz et al., 2021) provides a blueprint for scalable inclusivity in physical interaction design.

Table 3. Summary of Customizable and Adaptable Systems for Physical Differences

Key Finding	Recommended Adaptation	Example Technologies
AR systems must support mobility constraints	Multi-modal input (voice, eye-tracking)	AR assembly tools
Blind users benefit from auditory feedback in collaboration	Integrated auditory cues	Interactive tabletops
Adaptive interfaces improve satisfaction across physical profiles	Interface personalization based on input preference	Responsive UI platforms

Psychological Differences

Psychological factors, including personality traits, emotional states, and cognitive load thresholds, profoundly influence the way users interact with technology. Liu et al. (2023) showed that users experiencing loneliness or innovation resistance had distinctly different engagement patterns with AI voice assistants. Systems that offered personalized interaction styles, empathetic prompts, or simplified onboarding processes were better received by these users. Hu (2023) noted that cognitive overload in interface design leads to elevated anxiety and disengagement. This reinforces the importance of intuitive, low-friction interaction flows that guide users rather than overwhelm them. Attig et al. (2017) also demonstrated that personality traits such as playfulness and self-efficacy influence system exploration and satisfaction. This highlights the need for personalized complexity levels and optional engagement paths in interface design. Cockburn et al. (2017) further established that interaction sequencing, the order in which users encounter system features, can either enhance or hinder the experience. Linear, logically structured interactions were associated with greater satisfaction and lower mental fatigue. In immersive environments, Lee et al. (2024) observed that psychological comfort correlated strongly with both task completion time and error reduction, emphasizing the necessity of emotionally supportive feedback mechanisms.

Figure 5: Flowchart of Psychological Adaptations in AI Systems

Social Differences

Social dynamics, including cultural values, group interaction patterns, and platform-specific norms, affect how users engage with interactive systems. Oh and Sundar (2016) emphasized that demographic and cultural context shapes user expectations, suggesting that static design paradigms may fail across global user bases. To remain relevant, systems must support localized UI elements, multilingual interfaces, and culturally resonant content structures. Wei (2022) noted that barrage systems in digital platforms had a dual effect, enhancing real-time engagement but overwhelming some users, thus discouraging asynchronous interaction. This finding implies a design need for adaptive commentary filtering, where users can adjust the social intensity of their interaction experience. Van Erp and Toet (2015) introduced the notion of social touch in HCI, highlighting how tactile interactions with agents can simulate human-like presence and foster trust. This is especially valuable in socially isolated contexts, such as remote learning or virtual therapy. Jha and Verma (2023) found that platform-specific behaviors, such as short-form content engagement on Twitter versus long-form emotional content on Facebook, require designers to contextualize engagement strategies. Design must reflect the social rituals and interaction cultures of different platforms. Finally, Kostakos et al. (2005) warned of the social consequences of poorly designed technologies, noting that exclusionary or intrusive systems could harm interpersonal relationships or community cohesion. The authors call for a socially reflective design approach that considers long-term social interaction patterns.

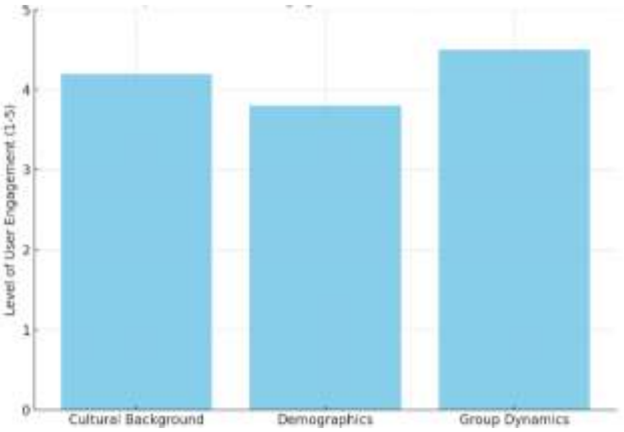

Figure 6: Comparison of User Engagement Across Social Contexts

Summary and Broader Implications

The collective findings of this review point to a shared conclusion: designing for diversity is not optional, it is essential for usability, adoption, and sustained user satisfaction. Across physical, psychological, and social dimensions, interactive systems must move beyond one-size-fits-all models and adopt adaptive, context-aware frameworks that evolve with user needs. The discussion affirms that user-centered design cannot be narrowly focused on usability alone. It must include emotional intelligence, cultural sensitivity, and physical accessibility as core design pillars. Such approaches not only improve functionality but also contribute to technological equity, ensuring that interactive systems support and empower all users, regardless of ability, background, or psychological profile.

CONCLUSION

This research underscores the central role of user diversity in the design and development of inclusive, effective interactive systems. By applying the People dimension of the PACT framework, the study has emphasized how physical, psychological, and social differences directly influence user interaction, satisfaction, and engagement. The synthesis of findings across more than 15 studies provides compelling evidence that interaction design must move beyond standardization toward personalization and adaptability. From a physical perspective, the review identified the necessity of offering multiple input modalities, such as voice, gesture, eye-tracking, and tactile feedback, to accommodate users with mobility, sensory, or motor control limitations. Systems like augmented reality platforms and collaborative tabletops can become significantly more inclusive when enhanced with multisensory and adaptive feedback mechanisms. Psychological diversity, including user traits like loneliness, resistance to innovation, and cognitive anxiety was found to shape how users perceive and engage with technology, particularly in AI-driven environments. Designing systems that are emotionally intelligent, intuitive, and supportive of cognitive well-being can foster more satisfying and stress-free user experiences. Social differences, rooted in culture, demographics, and group dynamics, emerged as equally important in influencing user behaviors. The review calls attention to the value of culturally adaptive interfaces and socially sensitive design that can foster trust, community, and positive engagement in both individual and collective contexts. Beyond usability, the findings also point to a broader opportunity: the creation of commercially scalable interactive systems that cater to diverse markets. Systems that are inclusive by design are more likely to gain traction across regions, user demographics, and application domains, enhancing market penetration, user retention, and brand trust. In summary, this research contributes to the expanding body of knowledge in human factors and ergonomics by advocating for user-centered, diversity-aware design principles. Future development of interactive systems should prioritize adaptability, inclusivity, and emotional engagement, ensuring that technologies remain accessible, functional, and meaningful for all users. In doing so, designers and developers can not only improve user experience and satisfaction but also drive innovation and competitiveness in an increasingly diverse and globalized digital landscape.

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