Applying Theory of Mind to Personalize AI for Supporting Life Transitions

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ABSTRACT

Life transitions, intrinsic to the human condition, evoke complex and nuanced mental states. While existing research predominantly addresses providing social support to assist individuals through such transitions, the potential of personalized technological support remains under explored. This literature review examines the feasibility of leveraging artificial intelligence (AI) to infer mental states and explores the rich landscape and expansive potential of personalized interaction design based on this mental state inference. Such designs advocate for the integration of AI's Theory of Mind (ToM) capabilities, aiming to foster more natural and intuitive user interactions by aligning with individuals' mental states. Despite these ongoing advancements, current applications are fragmented, often targeting a narrow spectrum of mental states within specific contexts. This underscores the necessity for a comprehensive exploration to guide the development of AI systems attuned to the intricate web of users' mental states. At the end, we also address the ethical implications of deploying such AI systems, with a focus on potential emotional repercussions and privacy concerns.

CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**.

KEYWORDS

Theory of Mind, Life Transitions, Personalization, Mental States

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1 INTRODUCTION

Life transitions mark pivotal moments in an individual's journey, encompassing significant shifts in personal and professional life. These transitions often result in the emergence of new routines, identities, roles, and relationships, while also giving rise to complex psychological effects, including stress, anxiety, and isolation, which have been substantiated by notable research [4, 14]. Within the realms of HCI and CSCW, there has been a longstanding interest in how technology can facilitate these life transitions, particularly through enhancing social support networks [16, 28, 47]. However, there remains a noticeable gap in research focused on leveraging technology to support individuals at a personal level during such transitions. The few studies that have ventured into this domain have adopted a health informatics perspective, centering on behavior tracking and data interpretation [8, 19]. Recognizing this gap, our study is poised to explore the potential of AI technology in providing personalized support to individuals navigating life transitions. This inquiry is crucial, given the subjective and inherently complex nature of life transitions [1], which demands a nuanced understanding of the individual's experience to tailor support effectively [4]. This literature review embarks on exploratory efforts to bridge existing gaps by employing the theoretical lens of Theory-of-Mind (ToM). ToM refers to the innate human capacity to attribute a full spectrum of mental states, including goals and knowledge, to ourselves and others, which allows us to understand and predict behavior [3]. Previous research has highlighted the capacity of HCI technologies to infer human mental states [29], and the interaction design that can adapt to these mental states [45], laying the groundwork for our investigation. Therefore, we argue that gaining insight into users' mental states, especially during significant life changes, and personalized interaction accordingly, offers a promising avenue for providing individual-level support throughout these transitions.

2 LITERATURE REVIEWS

In this literature review, we aim to delve into a range of interrelated themes that enable AI technology to support individuals through life transitions by understanding and responding to their mental states. Our analysis is organized into three primary areas. Initially, we explore the dynamics of life transitions, emphasizing the mental states encountered during these phases and the design of technologies tailored to address these challenges. Next, our examination broadens to encompass the detection of mental states through HCI technologies, along with the potential for incorporating ToM into their design. Finally, we investigate the ongoing efforts within HCI to develop interactions that are informed by users' mental states.

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2.1 Life Transitions and Mental States

Life transitions, seen as pivotal moments in an individual's journey, often mark personal growth over the long term, while leading to a decrease in well-being in the short term. Scholars have devoted considerable effort to categorizing these transitions. For instance, Mikal et al. [30] identified four primary domains of transition: health-illness (individual), development (familial), organization (community), and situational (societal). Meanwhile, Haimson et al. [17] introduced the Major Life Events Taxonomy framework, which covers 121 events across various categories, including Health, Career, Education, Societal, Identity, and more. These transitions frequently lead to the development of new routines, identities, roles, and relationships, while also triggering complex psychological effects such as stress, anxiety, and isolation, which have been well-documented in research studies [4, 14]. For example, the transition period after college, often celebrated with graduation, can bring about stress due to the challenges of securing post-graduate plans, such as finding employment or furthering education, moving to new locations, and adapting to new living situations, all of which can significantly affect life satisfaction [14]. Rather than focusing solely on specific transitions, recent studies, like the one by Zhang et al. [47], explore the effects of various major life events and the role of social support and identity exploration across multiple online platforms. This broadened perspective helps to better understand the multifaceted nature of life transitions and their impact on individuals.

Within the realms of HCI and CSCW, there has been a sustained interest in exploring how technology can aid individuals during various life transitions, especially by bolstering social support networks [16, 28, 47]. Despite this, there's a noticeable research gap in utilizing technology to provide personalized support at individual levels during these transitions. The limited research that does exist in this area tends to focus on health informatics, emphasizing behavior tracking and data interpretation [8, 19].

The concept of life transitions is inherently subjective, leading to the argument that there should be more exploration into providing personalized support at the individual level. Anderson et al. [1] highlighted this by defining a transition as such only if it is perceived to be one by the person experiencing it. Similarly, Kruzan et al. [23] pointed out that mental states, identified through online mental health screeners, could themselves mark transition points, validate young people's lived experiences of symptoms, and prompt consideration of subsequent actions. Recent research has underscored the impact of various mental states, such as stress, depression, and anxiety, during critical life transitions [14, 19, 47]. This underscores the importance of supportive interventions and highlights a starting point for offering personalized support to individuals during life transitions.

2.2 Techniques for Understanding the Mind of Human

Advancements in HCI technologies have led to a growing belief in their ability to discern people's mental states. This development spans various domains, including affective computing, which is dedicated to recognizing and reacting to users' emotional states through means such as social media post analysis and emotion recognition [36]. Furthermore, the realm of ubiquitous computing in general, has made strides by utilizing mobile sensors to gather data on human behavior and infer mental states from this behavioral data [29]. Research in brain-computer interfaces (BCIs) within HCI stands out for its unique sensitivity to the nuances of human mental states. This allows for tailored monitoring of individual mental progress, needs, etc., through the detailed interpretation of brain patterns linked to mental states. In educational settings, technologies like Electroencephalography (EEG) and functional near-infrared spectroscopy (fNIRS) are employed to assess vital cognitive processes, including mental workload, engagement, comprehension, attention, and self-regulation [26, 38]. The potential of technologies to infer mental states extends beyond educational uses, reaching a broad spectrum of applications and user groups. For instance, Hao et al. [18] used EEG to track affective states—specifically excitement and calmness—under stress, showcasing the technology's precision in measuring emotional reactions. Kopeć et al. [21] investigated the integration of BCI with smart home technologies from the perspective of older adults. This demographic showed a strong interest in BCIs for their potential to streamline diagnostic processes, enhance emergency responses, and support active, ambient, and assisted living scenarios. Notably, there is excitement about BCIs' ability to act during age-related emergencies, potentially even when the user is unconscious, highlighting their significant promise for diverse and impactful applications.

These innovations to sense and interpret users' mental states, are diverse, spanning various application scenarios and serving different groups of users, and they hold significant promise for AI technologies to meet the specialized needs of these groups. However, the complexity of individual needs highlights the necessity for systematic research. Customizing AI to meet these nuanced requirements requires a deep understanding of human mental states and how people expect AI to be designed based on these states.

ToM offers a theoretical lens through which to explore this issue. ToM is the cognitive ability that allows individuals to attribute mental states—such as beliefs, intentions, desires, knowledge, and emotions—to themselves and others [5]. Building on this concept, Merrill and Chuang [29] introduced the term "models of minds," which explores the intersection between human's beliefs about the mind, and the capabilities of technologies to assess and interact with these mental states, highlighting the HCI field's ongoing efforts to model human cognition. Furthermore, ToM is fundamental to human social interaction, enabling intentional communication, teaching, persuasion, team collaboration, and the development of shared plans and goals [3, 5, 43]. It is crucial for engaging in complex social behaviors like empathy, deception, and moral reasoning, thus playing a key role in the dynamics of human-computer interaction. In the computational realm, ToM has attracted attention for its potential to revolutionize HCI, human-AI collaboration, and the development of explainable AI systems [9, 42]. Wang et al. [42] highlighted the concept of mutual theory of mind, where AI is understood to possess human-like mental states, and humans have certain expectations of AI's capabilities. This concept is believed to be crucial for fostering natural and long-lasting human-AI interactions. It also serves as a foundation for complex collaborations, such as co-creativity [12], and for solving ill-defined problems in open-ended domains [22]. Research further emphasizes the importance of considering ToM in the development stage of AI, which is particularly crucial for enhancing AI's capability to accurately predict human actions in complex environments [9].

To summarize, many technology systems, such as affective computing, ubiquitous computing, and Brain-Computer Interfaces (BCI) are promising in detecting various mental states and processes. With these technological advancement, the integration of ToM abilities into AI has potential to develop systems that can comprehend and anticipate the human mind. This approach might foster more natural and intuitive interactions between people and technology, providing a valuable framework for designing technology that supports users' intricate mental states through various life transitions.

2.3 Personalize Interactions Based on Mind Inference

Personalized interaction is increasingly advocated for in several sectors, such as mental well-being. It includes matching digital mental health services to users' personality traits [20], and designing chatbot personalities that align with users' traits [32]. In the educational domain, personalization extends to considering users' interests [34] and customizing feedback [13]. This shift towards personalized interaction reflects a growing recognition of the value of tailoring digital experiences to individual users' needs and preferences.

While personalization is sought after, its implementation can be burdensome for users and often appears superficial in practice. For instance, Zargham et al. [46] discovered that users frequently express a desire for more customization and personalization features in their home assistants. They find the existing features to be inadequate, and also view the process of making adjustments themselves as challenging. On one hand, there are too many technical aspects to tweak to achieve a single desired outcome, such as modifying the speed, tone, volume, etc., to create the preferred voice of an agent. On the other hand, for individuals who are less tech-savvy, such as the elderly, making these adjustments proves to be difficult. Users would prefer if the AI could make these adjustments autonomously.

To minimize the load of personalization, implicit interaction, as a promising approach, has draw much research attention, with enhanced sensing capabilities and sophisticated inference mechanisms in technology. This new paradigm moves away from the traditional, deliberate, and attention-intensive methods of interacting with computers [45], and integrates the subtle monitoring of users' mental states instead, which is then combined with other direct inputs from the user, such as vocal commands or gestures, to enrich the context of the users' intended commands and states [37]. A widely recognized example of this approach is recommendation systems. These systems aim to deduce users' preferences to automate recommendations that achieve high satisfaction levels. However, mainstream recommendation systems typically rely on external factors, such as criteria set by experts, characteristics of the recommended content, and the context of users' behaviors; they often use superficial human-related metrics, if any, such as similarity to other users or demographic information [25].

The inclusion of complex mental states in recommendation algorithms, aimed at gaining a deeper understanding of users' minds, has shown promise. For example, research into cultural heritage design has highlighted the benefits of considering personal cognitive characteristics. This includes utilizing cognitive styles, which are defined as a person's preferred and habitual approach to organizing and representing information [33], and visual working memory [35]. These approaches have been shown to provide better content recommendations. Raptis et al. [35] further recommended a cognition-centered framework comprising a user modeling layer and a recommendation layer, aiming to support users' efficiency in processing visual information cognitively, ultimately enhancing user engagement and comprehension.

Although interaction personalization has traditionally given limited attention to people's mental states, many design efforts have actually begun to consider the nuances of these mental states. We discuss two primary strands within the field of interaction design, which, while distinct, are not mutually exclusive and could offer insights for personalization based on mental states. The first strand focuses on developing interaction supports tailored to various mental states or processes. This includes research aimed at modulating mental states to optimal levels, such as enhancing attention and reducing stress. For instance, D'Mello et al. [10] introduced intelligent interfaces capable of detecting when a user's mind wanders during computerized reading. By monitoring eye-gaze patterns and intervening with timely questions and suggestions for rereading, these interfaces have been shown to significantly enhance performance and productivity. Similarly, Szafir and Mutlu [39] developed agents that can monitor students' attention in real-time using EEG data, employing verbal and nonverbal cues to regain waning attention levels. In the realm of stress management, Balters et al. [2] explored data-driven approaches to deliver in-car, just-in-time stress management interventions for commuters. This research spans various intervention interfaces, including music [24], haptics [41], and integrated biofeedback designs. The latter, as discussed by Yu [44], dynamically adjusts its feedback source, information load, and interface modality based on the user's physiological state, offering a tailored approach to stress mitigation.

Another strand for exploration involves tools designed to enhance human activities by adapting to their mental states. Chang et al. [6] introduced a novel tool for reading scholarly articles, designed to assist researchers in understanding and contextualizing information more effectively. This tool personalizes visual enhancements and provides contextual information around citations by analyzing a user's activities, such as publishing, reading, and saving articles. Similarly, Thieme et al. [40] have focused on the integration of AI into internet-delivered Cognitive Behavioral Therapy (iCBT), employing a human-centered design approach. Their research aims to predict outcomes and improve the effectiveness of iCBT by ensuring that AI technologies align with clinical requirements and ethical standards, highlighting the potential of AI to offer customized and efficient mental health support.

People envision the capability of HCI technologies to comprehend the various mental states of humans and, through interaction, enable individuals to achieve their goals accordingly [11]. And there have been ongoing efforts in HCI to address this challenge. However, these efforts tend to be fragmented, focusing on specific scenarios and a limited range of mental states. The question of how to synthesize these findings to personalize AI technologies that can adapt to users' deep mental states in a comprehensive manner remains an open area of research.

3 DISUSSION: ETHICAL CONCERNS

Our study underscores the importance of addressing the ethical considerations behind the personalized AI-driven systems based on ToM. On the one hand, our literature review shows the promising benefits of AI technologies to support life transitions based on ToM (Ref 2.1 & 2.2), and highlights the importance of personalization based on users' mental states (Ref 2.3). On the other hand, we need to concern the potential adverse effects, such as impacts on users' emotions due to the emotional connection between them and the system [15]. AI promotes comfort and efficiency which may cause fewer human-to-human connections in some contexts [15]. Meanwhile, people may have emotion attachment to their software applications beyond perceiving them as a tool, and personalization is one of the strongest antecedents of information system attachment [7]. In addition, the analysis of the AI-based personal data may pose concerns regarding privacy [27]. Transparency and consent are seen as the key to providing users with information about data privacy [27]. Hence, it is crucial to meticulously evaluate the risks and benefits associated with various communication methods, alongside determining the specific content, manner, and timing for reporting the information. Moreover, just by inferring human mental states, may violate the privacy of people's minds in the first place. As Mittelstadt et al. [31] noted, personalization algorithms, which aim to influence users based upon claimed in-depth understanding of preferences, behaviours, and perhaps vulnerabilities of people, pose threats to the autonomy of users and their data privacy.

4 CONCLUSION

This literature review critically examines the frontier of personalizing AI to support individuals during life transitions, with a particular emphasis on understanding mental states through the theoretical lens of ToM. Our exploration indicates the multifaceted nature of life transitions, which are inherently complex and subjectively diverse, encompassing a broad spectrum of mental states that differ significantly among individuals. While HCI technologies have advanced in facilitating social support in this situation, they fall short in providing tailored support at an individual level. Despite the wide array of HCI innovations aimed at detecting and interpreting users' mental states across numerous contexts and for various user demographics, there exists an essential gap in synthesizing these efforts to guide the future design of AI systems. ToM emerges as a promising conceptual framework for addressing this challenge, advocating for AI designs that are more natural, intuitive, and grounded in an understanding of human mental processes.

Our review highlights a prevalent issue: the personalization of interaction often remains on a superficial level, lacking depth in integrating design strategies that truly reflect and respond to the complexity of human mental states. Current research and applications that do address mental states tend to adopt a fragmented approach, focusing on isolated elements rather than embracing a comprehensive spectrum. To overcome this limitation, we propose that future research should adopt a holistic view of mental states to pave the way for the development of AI systems that are genuinely personalized AI systems and sophisticated tailored to meet users' diverse needs.

Moreover, we delve into the ethical considerations of developing such personalized AI systems. The potential for adverse emotional impacts and privacy violations cannot be overlooked. These ethical challenges necessitate a careful, balanced approach to AI development, ensuring that systems are designed with the utmost respect for user autonomy, consent, and well-being.

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