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Design Principles and Interaction Strategies for Polyadic Chatbots

Abstract. Polyadic chatbots are conversational agents designed to facilitate interactions among multiple users simultaneously. These chatbots have become increasingly important in various applications, such as discussion facilitation, moderation, collaboration, and social companionship. The effectiveness of conversational design is crucial for maintaining user engagement and satisfaction, particularly in multi-user settings where poorly designed interactions can result in frustration or disengagement. The literature suggests that polyadic chatbots must be adaptable, accommodating diverse user preferences, input modalities, and ambiguous communication. This paper introduces a framework for designing polyadic chatbots, emphasizing the need for structured design guidelines to address the unique challenges of multi-user interactions. These guidelines aim to improve the user experience and ensure the efficiency and effectiveness of polyadic chatbots in various contexts.

Keywords: Polyadic chatbots, Framework, Design guidelines.

1 Introduction

Polyadic chatbots are conversational agents that can facilitate interactions among multiple users simultaneously. Recently, polyadic chatbots have become integral in several applications, such as discussion facilitation, moderation [1], partnership (collaboration) [2], and social companionship [3]. The development of polyadic chatbots demands a shift in design thinking that moves beyond traditional software development. Unlike conventional systems, chatbots operate in conversational spaces incorporating linguistic elements and visual and interactive components. For example, the conversational flow may become disjointed or unclear [4], particularly when several users are involved in a single interaction.

Moreover, the effectiveness of conversational design in chatbots is crucial for user retention and satisfaction. Well-designed chatbots facilitate natural and spontaneous dialogues, key to maintaining user engagement [5]. In polyadic settings, where conversations are more complex due to the involvement of multiple participants, poorly designed interactions can lead to user frustration or disengagement [6]. The literature emphasizes that polyadic chatbots must be designed with adaptability, as users' needs and preferences can vary widely [2]. This adaptability includes considerations for different input modalities, such as text or voice, and the chatbot's ability to handle ambiguity and interpret user intent accurately.

The need for design guidelines for polyadic chatbots becomes evident when considering the unique challenges posed by multi-user interactions. These guidelines aim at effectively managing complex multi-user interactions while promoting trust, fairness, and collaboration. They help enhance user experience, efficiency, and engagement

across various roles and contexts. This research paper introduces a framework for designing polyadic chatbots, addressing the need for trust, fairness, and adaptability in multi-user interactions to enhance collaboration and user satisfaction.

2 Literature Review

The advancement in natural language processing (NLP) has been substantial, allowing computers to understand and interact with human languages [7]. This progress has led to the emergence of Artificial Intelligence (AI) chatbots, or conversational agents, which apply NLP to streamline tasks and facilitate interactions through meaningful dialogues. [8]. These chatbots have gained widespread adoption in various industries, such as banking [9], healthcare [10], education [11], and e-commerce [12], utilizing their human-like interaction capabilities and cost-effectiveness to enhance service delivery.

According to recent market estimates, the chatbot industry is projected to reach a staggering $1.23 billion by 2025 [13]. Indeed, it has been found that nearly one-third of online interactions currently involve chatbot mediation [14]. The rapid proliferation of chatbots has brought about an increasing number of interactions between humans and chatbots, which, in turn, has a significant impact on the quality of services and online experiences [15]. Therefore, gaining a comprehensive understanding of the design space of chatbot-human interaction is of utmost importance.

The chatbot landscape is diverse and contingent on the chatbot's nature and application. Most contemporary studies focus on designing and developing dyadic chatbots, which involve one-on-one interactions between humans and chatbots [16]. Dyadic chatbots have been employed as personal assistants [17], healthcare partners [18], and customer service agents [19].

Research on chatbots has primarily focused on dyadic chatbots, while the literature on polyadic chatbots is still emerging [20]. Polyadic chatbots, or multiparty-based chatbots, are designed to address unique challenges not encountered by dyadic chatbots, such as social role-taking, social tension, and multiparty interactions [1]. These chatbots have been used across various domains, such as education [21], work and productivity [22], virtual meetings [23], guiding services [24], and games [25]. The functionalities of polyadic chatbots include prompting participants to engage in a discussion [26], coordinating the scheduling and management of tasks between team members [27], collaborative search [28], and reaching a consensus in a debate [29].

Existing literature review studies on polyadic chatbot technology have certain limitations in their scope and focus. Zheng et al. [1] limited their review to polyadic chatbots featured in ACM articles. The researchers focused on using polyadic chatbots to enhance communication, connection, and relationship maintenance. Ramandanis & Xinogalos [30] and Kuhail et al. [11] explored using dyadic and polyadic chatbots for educational purposes. Meanwhile, Poser & Bittner [31] and Ganesh et al. [32] examined using polyadic chatbots in task-oriented activities. Garg et al. [33] primarily focused on voice-based chatbots for children, while Almutairi et al. [2] explored the design challenges for dyadic and polyadic chatbots. While informative, existing review studies

have not addressed key components of polyadic chatbot design, such as communication modality, the communication problems that chatbots solve, the design principles used for chatbots, and the evidence for using chatbots in group settings. Moreover, the existing review studies do not fully represent the diverse applications and challenges polyadic chatbots face in various other contexts.

3 Framework

Figure 1 shows the framework used in this study to guide the design of polyadic chatbots. The numbers on arrows indicate the number of found papers that support the relationships. The framework begins with the outcome the user outcome. From there, we navigate to the chatbot's purpose designed to fulfill the outcome. The framework, then, explains the relationship with the user necessary to fulfill the chatbot purpose. The last column gives tips on the techniques used to build the intended relationship with the user.

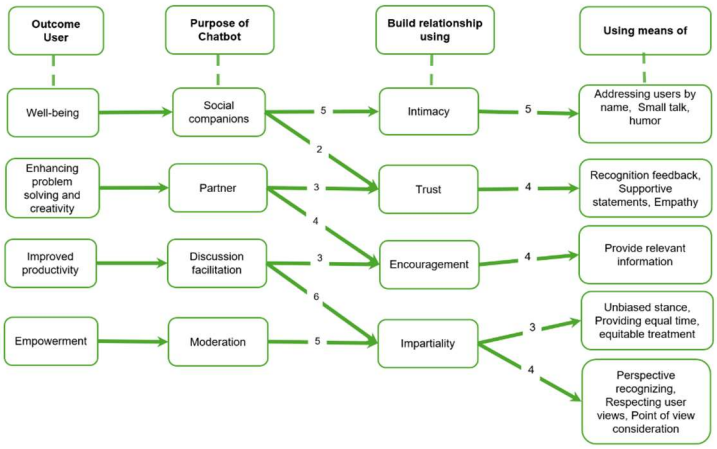

Fig. 1. *A framework for designing polyadic chatbots*

3.1 Social Companion

Social companionship is one purpose of polyadic chatbots, where the bot engages multiple users in social interactions. Trust is essential, as it fosters intimacy and improves communication. Although no chatbot specifically designed for trust was found, studies show that trust in a chatbot positively affects reuse intentions, as demonstrated by an emotional support bot in Hofeditz et al.'s work [34]. Chatbots that facilitate discussions, like the Mediator chatbot, also enhance trust by personalizing topics and fostering smoother conversations [35]. Intimacy is built through emotional responsiveness, as seen in chatbots using techniques like image recognition and small talk to make interactions more natural [36, 37]. Supportive feedback and transparency encourage user participation and effective communication [40, 41, 42]. For example, Bagmar et al.'s ArbiterBot sent time management alerts, helping keep discussions organized and efficient [44].

3.2 Partner

Partnership is a key function of polyadic chatbots, facilitating user collaboration to enhance problem-solving and creativity. Partnership chatbots build trust and encourage users to collaborate. For instance, Mirbabaie et al. [45] developed a chatbot that keeps dialogues organized, fostering trust as users connect with virtual assistants (VAs) and see them as reliable teammates. Encouragement also plays a vital role in motivating inactive members to engage more, as seen in mediator chatbots by Bagmar et al. [44] and Kim et al. [40] and facilitator chatbots by Do et al. [41, 42]. For example, Kim et al.'s chatbot improved dialogue quality by encouraging less active participants [40].

The design principles of emotionality and transparency help establish trust and encouragement. Emotionality involves feedback recognition and supportive statements, motivating users to participate more actively [40, 42]. Transparency provides relevant information to streamline discussions, as reported in Bagmar et al.'s chatbot, which sends alerts to manage time and maintain discussion efficiency [44]. These elements are crucial for partnership chatbots [44].

3.3 Discussion facilitation

The role of a discussion facilitation polyadic chatbot is to manage meeting sessions, improve communication, and promote equal participation. These chatbots encourage inactive members to engage more, ensuring balanced contributions [41, 42]. For instance, Do et al. [41] designed a chatbot that sent supervisory messages every 8 minutes to under-contributing members, which led to increased participation and more balanced discussions. Impartiality is also essential, as chatbots must supervise neutrally, making participants feel equally valued [42, 21, 31]. Poser et al. [31] developed a chatbot that facilitated idea generation by giving equal support to all contributors, ensuring fairness.

Encouragement is achieved through the design principles of emotionality and transparency, while impartiality is supported by fairness and perception-taking. Fairness is implemented by providing equal time and treatment to users, as seen in mediator chatbots that create neutral spaces for discussions [35, 40, 46]. For example, Niksirat et al. [46] designed MediationBot to moderate tensions impartially. Perception-taking involves recognizing and respecting user views, such as in Shin et al. [35], where mutual interests were identified through social media analysis. Wagner et al. [43] implemented understanding user perspectives, as seen in ArbiterBot's ability to acknowledge user input.

3.4 Moderation

A moderator polyadic chatbot helps users reach consensus, resolve conflicts, and improve conversation outcomes. Impartiality is crucial for building user trust and ensuring fair and inclusive collaboration [40, 43, 44, 35]. For example, Shin et al. [35] created a moderator chatbot that maintained objectivity by ensuring each participant had an equal opportunity to contribute, preventing conversation dominance. Similarly, Niksirat et al. [46] found that a moderator chatbot's effectiveness relied on its ability to give each party an equal say, which is crucial for conflict resolution. Impartiality, supported by fairness and perception-taking, is key for these interactions.

Fairness involves providing equal time and unbiased treatment. Niksirat et al. [46] demonstrated a chatbot's neutral stance in conflict resolution, while Wagner et al. [43] designed a chatbot that tracked time, ensuring fewer active users had opportunities to contribute. Perspective recognition, part of perception-taking, is seen in Shin et al.'s chatbot [35], which considered users' social media backgrounds to suggest relevant topics. Bagmar et al. [44] designed a chatbot that privately alerted users to inappropriate language, fostering conversation respect. These design principles ensure moderation chatbots are fair and considerate of users' views.

Conclusion

The framework proposed in this study serves as a guide for designing polyadic chatbots. It links user outcomes to chatbot purposes and the corresponding user relationships necessary to achieve those purposes. The framework highlights techniques for building effective user relationships, ultimately enhancing the chatbot's functionality.

For example, trust and intimacy are essential for fostering meaningful interactions among multiple users in social companionship settings. Design principles like naturalness and emotionality cultivate trust, including addressing users by name, facilitating small talk, and providing supportive feedback. Similarly, partnership-oriented polyadic chatbots rely on trust and encouragement to foster user collaboration, using transparency and emotionality principles such as real-time feedback and supportive statements to encourage participation.

In discussion facilitation, chatbots focus on fairness and encouragement to manage group dynamics, ensuring all participants are given equal opportunities to contribute. Impartiality, a key design principle, ensures neutral supervision of discussions, promoting balanced and productive conversations. Moderation chatbots, which facilitate

conflict resolution and consensus-building, also prioritize impartiality, leveraging fairness and perception-taking to ensure all users feel heard and respected.

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