AI Chatbot's Impact on Mental Well-Being and Its Potential Psychotherapy Effect: A Systematic Review

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Abstract. With the advancement of AI chatbots and increasing life pressure, AI chatbots, due to their diverse functions and accessibility, may serve as a viable option for promoting mental well-being. However, their actual impact and effectiveness on improving mental well-being still need further exploration. This paper examines the current psychological benefits of AI chatbots and the potential assistance their specific function offers to particular parts of mental well-being, based on relevant research published since 2020. The findings indicate that interacting with AI chatbots can moderately reduce psychological distress and enhance mental health levels. The interaction is more effective with more natural, human-like generative chatbot models; the right dorsolateral prefrontal cortex (rDLPFC) and bilateral ventrolateral prefrontal cortex (VLPFC) can regulate emotional regulation capabilities, which are crucial components of mental well-being, and by enhancing prefrontal cortex function through specific stimulation or employing emotional regulation strategies, individuals' emotions will be more positive; the neural mechanisms above represents the potential of integrating AI chatbot functions (role playing specifically) with existing psychotherapy methods. This paper offers new insights into the auxiliary role of AI within psychological treatment systems and its potential to promote individual mental well-being.

1 Introduction

Eliza, the first known chatbot, was created to serve as a psychotherapist by answering users' queries [1]. Its reliance on simple pattern matching and a template-based response mechanism made it incapable of generating diverse text or engaging in truly deep, interactive conversations [1]. Today's AI models, like ChatGPT 4.0, have shown remarkable performance in radiology and psychiatric licensing exams, and encouraging results in improving natural language processing capabilities [2]. This implies the possibility of genuinely human-like conversational interactions between humans and AI in the future.

The models and functions of AI advance and increase rapidly, so does the competition in the workplace and the pressure in life. High pressure may lead to low mood and even directly impact mental health. In the worst conditions, some people may struggle with depression and

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anxiety, unable to live normally. Nowadays, social media can serve as a platform to vent emotions. People use social media to varying degrees due to individual differences. For example, individuals experiencing more severe depression or anxiety symptoms tend to use social media more frequently [3]. However, excessive social media use may further exacerbate psychological stress [3]. This may be because online feedbacks do not necessarily align with the individuals' expectations. Therefore, people may fail to gain satisfaction and feel better. So, are there other personalized, dependable, and accessible solutions to help alleviate negative emotions and promote mental well-being? AI chatbots could be a possible option. However, in what specific aspects can AI chatbots promote mental well-being? How effective are they? And through which specific function can they bring these outcomes? These questions are valuable to discuss for exploring the efficacy of AI chatbots and future directions of integrating AI into psychotherapy.

This paper will conduct a meta-analysis based on relevant papers published since 2020, aiming to address the above questions and explore the role of AI chatbots in mental well-being. In addition, this paper will assess the effectiveness of AI chatbots in psychotherapy from a neuroscience perspective. The analyses can help clarify the potential applications of AI in mental well-being and the current research gap regarding AI's actual positive impact on mental well-being.

2 Definition of an AI-based chatbot and mental well-being

A chatbot is a computer program that engages in natural language conversations with users via text or voice and functions as an interactive human–computer interface in applied contexts such as psychological support [4]. By using technologies of artificial intelligence, such as Natural Language Processing (NLP), it understands user intent, simulates dialogue, and generates responses [4]. The response-generating strategies used can be used to classify the types of AI chatbots. These strategies can be roughly classified into two groups: retrieval-based and generative [5]. Depending on the user's provided keywords, the retrieval-based chatbot uses predefined dialogue libraries and rules to select the most relevant pre-written response from the library [5]. For example, Woebot, which utilizes natural language processing, can provide patients with cognitive behavioral therapy, psychological monitoring, psychological pattern analysis, and psychological status improvement through conversations [4]. Such mental health service chatbots can serve as an assistant and extension of professional medical care by providing low-intensity psychological support beyond clinical settings. Although the interactive experience may be less engaging than with a generative chatbot, such a chatbot provides more professional responses. A generative chatbot uses generative models to dynamically produce completely original, contextually relevant responses. For example, Replika uses LSTM technology, a deep learning model frequently used for sequence generation (e.g., text, dialogue) [5]. This explains why, in comparison to a retrieval-based chatbot, it displays more adaptable and natural conversational patterns; it can satisfy socializing, role-playing, and emotional comfort demands with customisable tales and AI avatars.

The relationship between terms related to well-being, as well as the distinction between mental well-being itself and its constituent elements or determinants, is currently rather confusing. Therefore, there is currently no universally agreed operational definition of mental well-being in empirical research [6]. However, current research usually uses psychosocial outcomes to represent this concept. The measurement methods are typically standardized scale scores, which provide quantitative results. For example, Fang et al. used the UCLA Loneliness Scale (ULS-8) to assess social isolation as one of four core psychological outcomes [7]. At the same time, since subsequent citations contain both "mental health" and "mental well-being", this distinction requires clarification in this section. According to the

World Health Organization (WHO), mental health is a state of well-being in which individuals can cope with the stresses of life, recognize their own potential, work and learn effectively, and contribute to their community and socio-economic development, which is a fundamental human right [8]. According to Hammoudi Halat et al., work-life balance, job happiness, social support, and other aspects are all included in the term “mental well-being”, which generally refers to general health and life satisfaction [9]. Therefore, mental health is a core component of well-being. From a physiological standpoint, the amygdala-prefrontal cortex (PFC) circuit’s integration and adaptability are essential to mental well-being [10]. The foundation of mental health is effective emotional regulation supported by adaptive neural coordination, or the cognitive control of emotions achieved through the interplay of the prefrontal cortex and amygdala [10].

3 The impact of AI chatbots on mental well-being

Li et al. included meta-analyses to assess how successfully AI-based conversational agents (CAs) promote psychological well-being and enhance mental health by lowering psychological discomfort [5]. 35 studies reached the inclusion criteria for the systematic review, and ultimately 15 randomized controlled trials (RCTs) were used in the meta-analysis [5]. Subgroup analyses indicated that one of the best groups for lowering psychological distress was generative AI-based CAs (as opposed to retrieval-based) [5]. RCTs that are part of the meta-analysis serve as the main foundation for the effectiveness comparison. A variety of control conditions, such as waiting, psychoeducation, and human control, were used to compare retrieval-based and generative CA therapies [5]. Psychological distress (including pain, anxiety, and depression) and indicators of mental health are used as the primary outcome measures to compare the treatment efficacy [5]. Standardized self-report questionnaires, such as Patient Health Questionnaire-9 (PHQ-9), were used in the trials [5]. The data showed a much greater effect size for generative CAs, and retrieval-based CAs produced a moderate effect size [5]. There was a statistically significant difference between these two types of models [5]. However, the impact of AI-based computer-assisted technology was not statistically significant on overall well-being [5].

The data reveal that CA’s effectiveness in lowering psychological distress is significantly moderated by the response-generating strategy. This discrepancy determines how well AI chatbots can mimic human dialogue, suggesting that generative models provide more lifelike and adaptable interactions.

Nevertheless, researchers failed to investigate the effects of particular AI models, since the sample size in generative AI research was too small (only 5 studies in systematic reviews and 4 in meta-analyses). This makes it impossible to draw conclusions about how other generative models, such as Generative Pre-trained Transformer (GPT), affect well-being differently [5]. Furthermore, generative AI learns and advances at a rapid pace, making it impossible to accurately reflect the current conversational capabilities of the model [5]. Finally, although the technique is identified as a moderator, no research included in this study empirically investigated the mediating or moderating impacts of variables that are theoretically associated with the response-generating approach, such as conversation quality or naturalness [5]. This suggests that the conclusion cannot clarify how the different approaches affect well-being. The causal relationship is currently not established.

The effects of AI chatbots on psychological outcomes have also been studied by Fang et al. [7]. The findings suggest that variations in psychosocial outcomes are correlated with usage patterns—usage length and user activity patterns—rather than directly caused by interaction design [7]. Higher levels of loneliness, emotional dependence, and problematic usage are linked to increased usage length and user characteristics, such as excessive emotional dependence on AI [7]. Together with the results from Li et al., interaction modes with more anthropomorphic traits, such as voice interaction, did not provide worse results. In addition, they made a substantial contribution to lessening negative psychological outcomes. All of these findings lend credence to the idea that anthropomorphic traits may help regulate and improve mental health. In contrast to the conclusions in Li et al., Fang et al. also pointed out that greater usage times could be associated with less social connection in real life [7]. This implies that restricting the length of conversations should be considered in psychological therapy so as to keep users from escaping from real-world interaction or becoming unduly dependent on AI. Considering the limitations, Fang et al.'s study was limited to American English speakers and lacked cross-cultural samples [7]. This reduces the generalizability of their conclusions.

In the study of Park et al., chatbots that actively engage in emotional self-disclosure (e.g., sharing their own emotional experiences) have been found to result in greater user satisfaction and willingness to reuse the service more successfully than those that only offer factual disclosure (objective information), such as Woebot [11]. The idea that people unintentionally adapt interpersonal social norms (such as intimacy and reciprocity) to human-machine interactions is supported by this conclusion as well as the conclusions of Fang et al. and Li et al. [5, 7, 11]. The distinction is that the research further identified three fundamental psychological pathways: cultivating closeness, eliciting user empathy and reciprocity, and a combination pathway that integrates both [11]. This helps to explain why human-like AI enhances users' mental well-being.

Eisenstadt1 et al. systematically reviewed and evaluated the effectiveness of mental health applications (MHapps) designed for the general adult population (aged 18–45) in promoting emotional regulation, positive mental health, and well-being [12]. Mood tracking, guided meditations, psychoeducation, gamification, narrative, and in-app notifications are among the elements that the apps have in common [12]. The study included 52 studies (involving 48 distinct MHapps), of which 39 were randomized controlled trials (RCTs) [12]. This relatively high proportion indicates that the study is supported by a solid methodological evidence base, making its conclusions comparatively reliable in terms of causal inference, rather than being primarily based on observational or descriptive studies. Quality assessments were conducted using the Mixed-Methods Assessment Tool (MMAT) and the Cochrane Risk of Bias tool (RoB-2) [12]. The data indicates 2 findings: the app has a small but significant effect on alleviating mental health symptoms (anxiety, depression, stress) and improving well-being; and the effect for enhancing emotion regulation is medium [12]. The apps are similar to AI chatbots because they are both based on positive psychology concepts and have the capability to improve users' mental health. Conventional apps without AI do not, however, have the flexibility to adjust their content provided according to individual differences. In comparison, AI chatbots like Woebot are able to dynamically modify intervention plans and customized workouts by examining users' language and emotional conditions [4]. They also offer low-cost, round-the-clock emotional support with the capacity for dynamic adaptation based on user input. However, when using the application, there is no need to consider the issue of emotional dependence. Emotional projection in AI interactions, as a major influencing factor, can actually reduce the efficacy of emotional regulation and mental well-being enhancement, as shown in Fang et al. [7].

In terms of research limitations, a large number of studies are pilot trials or feasibility studies [12]. This limitation is manifested in high dropout rates and insufficient sample diversity, which may affect the representativeness of the sample. Furthermore, the samples also don't provide qualitative information on user experience [12]. Quantifying emotions may not adequately reflect changes in user experience and mental health status, much like the previously discussed standardized scales.

4 Potential effects of conversations with AI chatbots on brain regions related to emotional regulation

As was covered in section 2, emotional regulation is linked to important brain regions and is an essential basis for mental health. Future uses of AI chatbots in psychotherapy can be influenced by investigating how chatbots affect mental health from a neurological standpoint. However, there are still few studies being done on direct neural-level connections with AI chatbots. In order to speculate how AI chatbots can indirectly activate certain brain regions for improved emotional regulation, this section focuses on and associates the role of brain regions in emotional regulation with the existing functions of AI chatbots.

Yu et al. investigated methods to enhance emotional regulation capacity by strengthening activity in the right dorsolateral prefrontal cortex (rDLPFC) through real-time neurofeedback training [13]. Unlike traditional neurofeedback training, which targets brain regions related to emotions (amygdala, for example) and may be detrimental to individuals with emotional disorders due to accompanying emotional stimulation, the rDLPFC belongs to a non-emotion-related brain region. 30 college students were allocated to two different groups: the neurofeedback group (NF) or the sham feedback group (Sham) [13]. Both groups were instructed to modulate rDLPFC activity through cognitive strategies such as mental arithmetic and spatial imagery [13]. The study employed functional near-infrared spectroscopy (fNIRS) for real-time feedback and resting-state functional magnetic resonance imaging (rs-fMRI) to analyze how the brain network connectivity was changing [13]. fNIRS was chosen because it excels at measuring superficial blood flow changes in the cerebral cortex, with the prefrontal cortex (including the rDLPFC) being a region where it demonstrates particular measurement strength. Furthermore, the study not only avoided emotional stimuli but also completely separated cognitive control training from emotional regulation [13]. A fundamental issue in traditional emotion regulation neurofeedback studies is confounding: participants simultaneously view emotional images while attempting to regulate brain activity. Consequently, this research methodology helps clarify whether training effects originate from enhanced emotion regulation capacity in specific brain regions or from the training's regulatory strategies themselves. According to research, people can improve their capacity for emotional regulation by modifying the rDLPFC in the absence of emotional stimuli [13]. The main mechanism is that improved cognitive control strengthens the top-down emotional regulation network connectivity, particularly between the emotional regulation network and the amygdala [13].

The participants were mostly students of higher institutions of learning, and the sample was very small (just 30 people) [13]. Therefore, it is possible that the results cannot be generalized to other age groups, like adolescents or the elderly, because the thinking process and the neural plasticity of those groups differ. Moreover, the improved Emotion Regulation Network (ERN)-connectivity was noted; however, additional studies should be conducted to explain which particular neural processes underlie the positive changes in behavior. Simultaneously, currently, direct and extensive studies on the effect of AI role-playing on emotional regulation do not exist [13]. Consequently, the conclusion that AI chatbots can be used in mindfulness therapy or can be used to help in cognitive reappraisal to increase the ability of VLPFC emotional regulation is yet to be experimentally proved.

In the article by Li et al., scientists examined the existence of differences in the role of the left and right bilateral ventrolateral prefrontal cortex (VLPFC) in the regulation of negative emotions and the ability of the VLPFC to regulate negative emotions, as well as extending the subsequent regulation of positive emotions [14]. The study has selected 120 healthy college students who were split equally between males and females [14]. All the participants were right-handed [14]. The reason is that language and cognitive control are associated with the left VLPFC, which is the area of the brain that will be under study in this study. This aspect of the intimate brain is required in the delayed cognitive reappraisal procedure, which is applied. Left-handed persons also could possibly process languages relying on different brain hemispheres (more on the right hemisphere) when related to reappraisal as compared to their right-handed counterparts, and this may influence the results of experiments. Regarding the study design, the between-subjects study independent variable consisted of three Transcranial Magnetic Stimulation (TMS) purposes in the stimulation of VLPFC: left VLPFC, right VLPFC, and sham stimulation [14]. The within-subjects variables were further broken down into two categories, which are social feedback (neutral, positive, or negative) and type of cognitive regulation (passive viewing or utilizing cognitive reappraisal strategy) [14]. First, participants rate the faces of other participants on photographs, and TMS stimulus was used, supposedly on some parts of the brain, in order to cause the increased states of readiness, which allowed the causal treatment of their effects on the way of handling the task [14]. Afterward, the participants saw images of the faces of the evaluators with social feedback, that is, with the score stating how this participant rated your photo [14]. The activity produced effects on the provision of emotionally meaningful feedbacks, like pride, disappointment, or social anxiety, by creating a realistic, two-way social assessment scenario [14]. Participation in the passive group merely involved the part of observation, whereas in the other group, the participants were required to control their emotions through the introduction of cognitive reappraisal [14]. The four indicators measured by this experiment included immediate emotional response after feedback, objective neural response (measured through amplitude of late positive potentials as measured using electroencephalography), scores during delayed recall tests, and the pre- and post-experiment ratings of liking to the face of the evaluator [14].

The research came to three conclusions: First, bilateral VLPFCs are involved in the regulation of social emotions, though the right VLPFC has a critical causal role; Second, the VLPFC has a causal role in the regulation of emotions, being able to both downregulate negative emotions and upregulate positive emotions. Third, emotion regulation (though not necessarily cognitive reappraisal) may affect the future social ratings of evaluators through changes in the content of memories linked to social feedback [14].

In general, these results correspond to the experimental results of Yu et al. on the emotional regulatory role right VLPFC plays. The difference is that this study has offered a cause and effect through TMS and by introducing a positive social feedback, as an independent variable, has expanded the usefulness of this brain region in the effort to increase the positive social reward. Moreover, social feedback is used, in which the internal validity and the ecological validity of the experiment will be balanced.

The design of the experiment implied the use of memory and evaluation tasks following the emotion regulation task [14]. This can create order effects, because the performance of the next task may be affected by fatigue or practice during the previous task. The authors, however, mention that the difference between the three groups (TMS effects) was significant only in the reappraisal group and not in the passive viewing group, which lowers this confound to some level [14]. Also, the analysis was conducted on the VLPFC alone, as compared to emotional regulation, which is a huge network. Including more discussion of other regions that are related to each other, like the anterior cingulate cortex or insula, would have resulted in a more comprehensive description of emotion regulation networks.

Section 2 stated that role-playing needs can be achieved through AI chatbots, in particular, generative ones. Role-playing is associated with psychological processes, such as emotional perceptions, emotional expression with the help of language, and mental reevaluation.

In the article, Chen et al. focus on a systematized review of the literature and products on the topic of role-playing agents (RPLAs) relying on large language models in academia and industry [15]. There are three progressive types of roles in the article, including demographic roles (appropriate when conducting group simulations and suchlike), character roles (appropriate when patients seek entertainment and emotional companionship), and personalized roles (appropriate when patients require a personal assistant and suchlike) [15]. Despite an evident direction of incremental development, there exist technical constraints. First, existing large language models (LLMs) /RPLA do not have an actual theory of mind and profound sympathy, which can be surface-level interactions or self-centered [15]. At the same time, AI chatbots can hardly be confident in the ability to extract and integrate character information in long texts and be consistent over time [15]. All these undercut the naturalness and the coherence of AI chatbots because they reduce the user experience. Finally, the use of RPLA in the long term can cause such issues as the psychological dependence of the users, the loss of social skills, and the loss of reality, as revealed by Fang et al. as well [7, 15].

Shanahan et al. is also a systematic review, targeting a study of conversational agents in LLMs, including ChatGPT [16]. The conclusion implies that the use of role-playing is capable of preventing anthropocentrism and would still retain the naturalness of dialogue descriptions [16]. As a result, the given functionality helps users to logically plan and use AI chatbots and be fully aware of the fact that they are only acting. This reduces fears of users becoming too dependent on the emotional reactions of AI chatbots. This finding, however, has not undergone large-scale experiments to confirm it. As with the study by Chen et al., there are not many discussions on controlling the role-playing actions of conversational agents and eliminating ethical concerns when using them in a practical application.

5 Discussion

Despite the fact that the specific neurological mechanisms have not been properly explained yet, the improvement of mental health through the use of AI chatbots can be deduced since quantitative implications are determined according to the summaries of the works that are presented in this paper.

Concerning the theoretical validity, the scientific literature presented above only tests the improvements in mental well-being within a single study; most of the studies do not include long-term follow-ups, which do not provide information on how the observed effects regarding mental well-being will be enduring. Mental well-being depends on both long-term and short-term variables. Thus, long-term follow-up research is required to demonstrate the legitimacy of the effect of AI chatbots on mental health in real-life situations. Simultaneously, it exists that nowadays there is no direct and comprehensive study of the effects of AI role-plays on emotional regulation [13]. Thus, speculation on the possibility of AI chatbots to incorporate mindfulness treatment or help to engage in cognitive reappraisal in order to develop better capabilities of VLPFC emotional regulation remains to be experimentally tested. Lastly, since the human brain is complicated, the other direct or mediating variables that affect the results of emotional regulation are not well understood. The emotional regulation capacity is just one of the pillars of psychological health, and there are other pillars that can be changed by AI chatbots, but this paper does not address them.

Considering the application facet, in terms of how AI chatbot answers are generated, the best mental health improvement outcome is to strike the right balance of being distant and being able to interact with a human-like effect. Nevertheless, the lack of compatibility of the current information filtering and ethical constraint technologies with the needs regarding flexibility and damage control in a timely manner, as well as the fact that interactions between people are defined exclusively by the use of LLMs and human instructions, makes the interactions less suitable to suit the requirements of the latter. Hence, people are advised to be cautious of forming a polluted emotional dependence on the AI chatbots, especially without professional presence. In case of severe mental disorders or underdevelopment of cognitive maturity, it is much better to address real-world counselors. In the meantime, AI chatbots are not yet in a position to provide personalized experiences completely. In actual life, the social relationships that exist usually involve years of association and communication. Nevertheless, at this point, existing AIs do not have well-developed long-term memory features [15]. This limits their capability in providing consistent long-term psychological care. Moreover, offline communication requires multi-channel emotional communication with body language and facial expressions, which AI chatbots are still only partially able to provide these days in the form of relatively developed voice and text communication. As a result, it is very difficult to find an ideal match with certain usage situations, which include the most wanted role-playing. Large and regular user instructions can also either disorient or induce forgetfulness in the AI about the past discussions. Nevertheless, AI chatbots, which have a high level of guidance and focus on professional mental health care, are relatively mature and in the open market (e.g., Woebot). The further evolution of AI chatbots in improving mental health is still a possibility.

6 Conclusion

This paper is a systematic literature review on the effects and therapeutic support of the existing AI chatbots on mental health and how natural conversations with generative AI chatbots affect the emotion regulation abilities of the prefrontal cortex, as well as the potential future role of certain AI chatbot functions in the emotion regulation ability of the prefrontal cortex. More naturalistic dialogues and the development of role-playing features can be the new avenues in the evolution of AI chatbots. Nonetheless, regardless of the current advances, more focused, detailed, and direct impacts of AI chatbots on mental health remain to be supported in the course of additional research. More interdisciplinary studies will be needed in the coming days to analyze further functionalities and applications of AI chatbots, and to address the ethical issues related to them in a more comprehensive and cautious manner when implementing them. In addition, further narrower and more detailed studies are required on the possible adverse effects, including the problems concerning security, accuracy, and privacy of responses, to assist future generations to learn the right degree of use of diverse applications. The possibilities of the AI chatbot-assisted psychotherapy discussed in the paper described above might not only contribute to the overall effectiveness of the healthcare systems but also enable citizens to find their way to mental health in contemporary life, therefore, reaching a greater quality of life.

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