Journal of Orange Technology (JOT)
Vol. 1, No. 1, October, 2024, pp. 39−50
E-ISSN: XXXX-XXXX | P-ISSN: XXXX-XXXX, DOI:10.34306

Sentiment Aware Chatbots as Companions for Reducing Loneliness through Positive Computing

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Article Info

Article history:

Submission September 6, 2024
Revised September 29, 2024
Accepted October 9, 2024
Published October 19, 2024

Keywords:

Sentiment Aware Chatbots
Positive Computing
Loneliness Reduction
Compassionate Artificial Intelligence
Psychological Well-being

ABSTRACT

Loneliness has increasingly emerged as a global mental health concern, particularly among vulnerable populations such as the elderly, students in remote learning environments, and individuals experiencing social isolation in urban societies. Advances in affective and positive computing offer promising solutions for addressing these challenges by creating empathetic digital companions capable of responding to human emotions in real time. This study aims to evaluate the effectiveness of sentiment-aware chatbots as digital companions in reducing loneliness and enhancing emotional well-being through positive computing principles. **A quantitative experimental approach** was employed, integrating sentiment analysis algorithms with Natural Language Processing (NLP) to detect emotional cues from user input and generate empathetic responses. The chatbot system was tested with 150 participants over a six-week period using standardized psychometric instruments, including the UCLA Loneliness Scale and the WHO-5 Well-Being Index. **Statistical analysis revealed significant improvements** in loneliness reduction and psychological well-being among participants interacting with the sentiment-aware chatbot. Furthermore, perceived empathy and user satisfaction were found to mediate these effects, highlighting the emotional quality of human AI interaction as a crucial determinant of positive outcomes. **These findings provide empirical evidence** that sentiment-aware chatbots can function as effective digital companions, reducing loneliness and fostering psychological resilience. By integrating affective and positive computing principles, **this study contributes to the advancement of compassionate AI systems** designed to promote human well-being and support broader societal goals.

DOI: https://doi.org/10.34306/jot.v1i1.10

1. INTRODUCTION

Loneliness has been recognized as a pervasive issue that negatively affects both mental and physical health across diverse populations worldwide. According to recent reports by the World Health Organization, more than 970 million people suffer from mental health disorders, with loneliness and social isolation serv-

ing as critical risk factors for anxiety, depression, and decreased life satisfaction. The COVID-19 pandemic further amplified this challenge by restricting face-to-face interactions, leaving many individuals vulnerable to prolonged isolation [1]. Consequently, there is an urgent need for innovative, technology-driven solutions that not only provide assistance but also address the emotional and psychological dimensions of human well-being [2, 3].

In recent years, Affective Computing and Positive Computing have emerged as promising interdisciplinary fields that integrate computational intelligence with humanistic principles. These approaches emphasize designing systems that can detect, interpret, and respond to users' emotional states, fostering meaningful interactions that promote happiness, empathy, and resilience. Within this paradigm [4], AI-driven conversational agents, or chatbots, have gained significant attention as digital companions capable of providing emotional support and social engagement. Unlike conventional software systems, chatbots simulate human conversation, allowing users to express feelings and receive timely, context-sensitive feedback. However, most traditional chatbots still rely on rule-based or predefined response structures, lacking the capacity to understand nuanced emotions or adapt to users' affective states. This often results in mechanical interactions that fail to reduce loneliness effectively [5, 6].

To overcome these limitations, the concept of sentiment-aware chatbots has been introduced as a novel and more emotionally intelligent alternative. By leveraging Natural Language Processing (NLP) and sentiment analysis, sentiment-aware chatbots can identify affective cues in user input such as tone, polarity, or emotional intent and generate empathetic, contextually appropriate responses. This capability allows them to respond not just to what users say, but to how they feel, thereby enhancing relational authenticity and emotional engagement. Through this process, users experience interactions that are perceived as more genuine, supportive, and emotionally resonant. As a result, sentiment-aware chatbots are increasingly regarded as potential digital companions capable of alleviating loneliness and promoting psychological well-being [7].

Emerging evidence supports the therapeutic and social potential of these systems. Studies indicate that emotionally aware conversational agents can foster companionship, reduce perceived social isolation, and enhance users' sense of being understood [8, 9]. Furthermore, advances in affective modeling and adaptive dialogue management have enabled chatbots to continuously learn from user interactions, improving their empathy over time and aligning their responses with users' emotional patterns. Such dynamic responsiveness aligns with the broader vision of compassionate AI, which seeks to integrate emotional intelligence into technological design to achieve psychological and social benefits for users.

Despite promising developments, several gaps remain in the current literature. Existing studies often focus on limited user populations, such as young adults or patients in short-term interventions, leaving the long-term psychological effects of sentiment-aware chatbot interactions underexplored. Additionally, factors such as perceived empathy, user satisfaction, and emotional authenticity are not yet fully understood in relation to loneliness reduction. These constructs play a vital mediating role in determining how users internalize and emotionally respond to digital companionship. Moreover, ethical concerns such as data privacy, emotional dependency, and the authenticity of machine-generated empathy present further challenges that must be addressed to ensure responsible deployment of these systems [10, 11].

Therefore, this study builds upon the intersection of affective and positive computing to investigate the design, implementation, and evaluation of sentiment-aware chatbots as digital companions. Specifically, it aims to assess their effectiveness in reducing loneliness, to explore user perceptions of empathy, and to examine how adaptive, emotion-sensitive interactions contribute to users' overall psychological well-being [12, 13]. By integrating affective recognition algorithms and positive interaction strategies, the present research seeks to contribute to the advancement of compassionate AI one that prioritizes human emotional needs alongside technical sophistication. Ultimately, the findings of this study are expected to deepen understanding of how emotionally intelligent systems can foster meaningful human–machine relationships and promote mental health in an increasingly digital world [14, 15].

2. LITERATURE REVIEW

The emergence of sentiment-aware chatbots represents a transformative development in the intersection of affective computing, artificial intelligence, and human computer interaction. In recent years, digital companions have evolved from rule-based information systems to emotionally intelligent agents capable of understanding users' affective states and responding empathetically [16, 17]. These systems are increasingly

integrated into social, educational, and healthcare contexts to address emotional challenges such as loneliness, stress, and depression through supportive conversational experiences [18].

Loneliness, defined as the perceived discrepancy between desired and actual social relationships, has become a growing concern in modern societies, particularly among young adults and older populations. Traditional interventions, such as counseling and peer support, are effective but often limited by accessibility and cost [19]. In this regard, AI-driven chatbots provide a scalable and cost-effective solution for delivering emotional support. Prior studies show that conversational agents can simulate companionship, promote social connectedness, and foster feelings of being understood through natural and affective dialogue [20, 21].

From a theoretical perspective, the foundation of sentiment-aware chatbot design lies in Affective Computing Theory and the Positive Computing Framework. Affective computing, as introduced focuses on developing systems that can recognize, interpret, and express human emotions. Positive computing extends this approach by emphasizing technological design that enhances human well-being and flourishing [22, 23]. Within this framework, chatbots function not merely as information processors but as emotionally responsive companions designed to strengthen psychological resilience and promote positive emotional states [24, 25].

Sentiment awareness is the central mechanism that enables these systems to operate empathetically. By leveraging Natural Language Processing (NLP) and sentiment analysis, chatbots can detect affective nuances in user input and generate responses that align with users' emotional tone. Demonstrate that such empathetic alignment can significantly improve user satisfaction and reduce perceived loneliness [26, 27]. Furthermore, reinforcement learning algorithms allow chatbots to adapt dynamically to users' emotional patterns, improving the authenticity and continuity of interaction over time.

Recent empirical evidence underscores the psychological impact of sentiment-aware interactions. For instance, found that AI-driven empathetic dialogues reduced loneliness scores and improved WHO-5 well-being indices among participants over a six-week trial. Similarly reported that perceived empathy mediates the relationship between chatbot engagement and emotional recovery [28], suggesting that users' subjective experience of empathy is a critical determinant of psychological benefit. These findings highlight that technological sophistication alone does not guarantee emotional effectiveness; rather, the perception of empathy and relational authenticity plays a decisive role in user acceptance and emotional outcomes.

Another essential factor identified in recent literature is user satisfaction, which functions both as a predictor of continued chatbot use and as a mediator of psychological well-being [29, 30]. User satisfaction reflects not only the functional performance of the system but also its emotional resonance and conversational naturalness. When users perceive that a chatbot "understands" and "responds appropriately" to their emotions, satisfaction increases, leading to greater engagement and cumulative psychological benefits. This dynamic mirrors theories in human computer interaction emphasizing reciprocity and relational bonding between humans and AI entities [31].

Taken together, existing research demonstrates that sentiment-aware chatbots hold substantial potential as digital therapeutic companions. They combine technological intelligence with affective sensitivity, enabling meaningful, empathetic exchanges that can alleviate loneliness and enhance mental well-being. However, despite promising results, prior studies often focus on specific populations or short-term outcomes, leaving gaps in understanding the long-term emotional effects and cross-cultural adaptability of these systems [32, 33]. Therefore, the present study seeks to extend this discourse by empirically examining how sentiment-aware chatbots influence loneliness reduction and psychological well-being, and how perceived empathy and user satisfaction mediate these effects within a positive computing framework [34].

3. RESEARCH METHOD

This study employed a quantitative research design to evaluate the effectiveness of sentiment-aware chatbots in reducing loneliness and enhancing psychological well-being. A quantitative approach was selected because it allows for systematic measurement, statistical comparison, and hypothesis testing, enabling objective evaluation of relationships among variables. The research process consisted of several key stages: literature review, model development, variable operationalization, data collection, and statistical analysis [35]. The literature review was conducted to establish the theoretical foundation of the study by identifying prior findings in affective and positive computing. Based on these insights, a conceptual model was developed linking the independent variable (sentiment-aware chatbot interaction) with two dependent variables loneliness reduction and psychological well-being mediated by perceived empathy and user satisfaction [36, 37].

In the subsequent stages, each construct was operationalized using validated psychometric instruments, including the UCLA Loneliness Scale, the WHO-5 Well-Being Index, and adapted empathy and satisfaction measures. Data were collected through a pre-test post-test experimental design in which participants were randomly assigned to either a control group (conventional chatbot) or an experimental group (sentiment-aware chatbot) [38]. Statistical analysis was conducted using SPSS and AMOS. Descriptive statistics summarized participant characteristics, while paired sample t-tests and ANOVA evaluated within- and between-group differences. Structural Equation Modeling (SEM) was further applied to examine both direct and indirect relationships among variables and to test the mediating effects of empathy and satisfaction. This structured methodological framework ensured the validity, reliability, and robustness of the study's findings [39, 40].

3.1. Research Framework

Based on the theoretical foundation, this study proposes a model in which sentiment-aware chatbot interaction serves as the independent variable (X), while loneliness reduction and psychological well-being serve as dependent variables (Y1, Y2). Mediating constructs such as perceived empathy and user satisfaction are also examined to provide a more comprehensive understanding of the relationship between chatbot features and user outcomes [41].

$$\textit{Effectiveness of Chatbot} = f(\textit{Sentiment Awareness, Perceived Empathy, User Satisfaction})$$

This formulation emphasizes that the effectiveness of a sentiment-aware chatbot in addressing loneliness and enhancing psychological well-being depends not only on its sentiment analysis capability, but also on how empathetic and satisfying users perceive the interaction to be. In this regard, the chatbot's technical ability to recognize and respond to emotions must be complemented by users' perceptions of empathy and satisfaction to generate meaningful outcomes. The mediating role of perceived empathy highlights the importance of human-like responses and emotional support [42, 43], while user satisfaction reflects the overall quality, usefulness, and engagement experienced during the interaction [29].

Accordingly, the proposed framework integrates both technological capabilities and psychological constructs to ensure a holistic evaluation of chatbot effectiveness. This aligns with contemporary perspectives in human computer interaction research, which stress that user experiences, perceptions, and emotional engagement are central to determining the success of intelligent systems. The overall framework of this study is illustrated in Figure 1, which visualizes the causal pathways between the independent variable (sentiment-aware chatbot interaction), the dependent variables (loneliness reduction and psychological well-being), and the mediating constructs (perceived empathy and user satisfaction) [44].

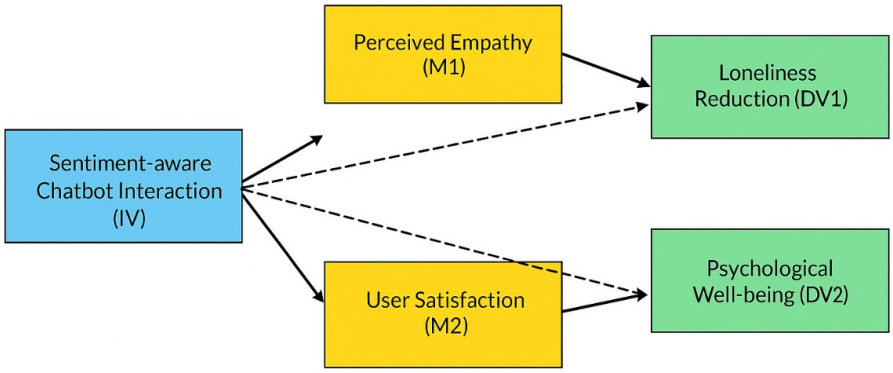

Figure 1. Sentiment-aware Chatbots for Reducing Loneliness

The research framework in Figure 1 illustrates the relationship between sentiment-aware chatbot interaction as the independent variable and two dependent variables, namely loneliness reduction and psychological well-being. In this model, the effectiveness of the chatbot is not only influenced by its ability to recognize user sentiment but is also mediated by two critical constructs: perceived empathy and user satisfaction. Perceived

empathy represents the extent to which users feel that the chatbot conveys empathy during interactions, while user satisfaction reflects the overall level of satisfaction with the interaction experience. The direct and indirect relationships, indicated by solid and dashed arrows in the diagram, emphasize that the success of the chatbot in reducing loneliness and improving psychological well-being depends on a combination of sentiment analysis capabilities and the emotional quality of user experience. Thus, this framework highlights the importance of developing chatbots that are not only technically intelligent but also empathetic and capable of fostering meaningful and satisfying user interactions [45].

3.2. Research Design

A pre-test post-test experimental design was adopted to evaluate the effectiveness of the sentiment-aware chatbot intervention. This design enabled comparison of participants' psychological states before and after interaction, while controlling for potential confounding factors. Participants were randomly assigned to two groups to ensure internal validity and minimize selection bias:

- **Control Group** : Interacted with a conventional chatbot without sentiment awareness, providing standard rule-based responses.
- **Experimental Group** : Interacted with a sentiment-aware chatbot equipped with *Natural Language Processing* (NLP) and *sentiment analysis* to detect emotional cues and respond empathetically.
- **Assessment Procedure** : Both groups completed pre-test and post-test measurements using standardized loneliness and well-being scales.

Each participant engaged in chatbot sessions over a six-week period, with interactions conducted three times per week for approximately 15–20 minutes per session. All interactions were recorded for analysis of response patterns and emotional engagement. This design ensured adequate exposure to the intervention and allowed for robust comparison between conventional and sentiment-aware chatbot conditions.

3.3. Participants and Sampling

Participants were recruited through online platforms and university mailing lists to ensure a diverse pool of respondents from various academic and social backgrounds. The inclusion criteria required that participants: (1) self-report moderate to high levels of loneliness, (2) be fluent in English to effectively engage in chatbot interaction, and (3) provide informed consent prior to participation. These criteria were established to guarantee that the sample was both ethically valid and relevant to the research objectives.

A minimum of 100 participants was targeted to ensure statistical reliability and robustness of the findings. This threshold was determined by considering power analysis guidelines and previous studies in related domains, which suggest that a sample of this size provides sufficient power for hypothesis testing and generalization. The design further aimed for an equal distribution across control and experimental groups to reduce potential biases and strengthen internal validity.

By adopting this recruitment and sampling approach, the study seeks to balance methodological rigor with practical feasibility. Online recruitment through digital platforms and institutional mailing lists increases accessibility, while the defined inclusion criteria ensure that participants share the characteristics necessary for meaningful interaction with the sentiment-aware chatbot. This careful selection process strengthens the reliability of the dataset and enhances the potential applicability of the study's findings.

3.4. Instruments and Measures

To ensure the validity and reliability of the findings, several standardized instruments were employed to measure the main constructs of this study. Each instrument was selected based on its established psychometric properties and its suitability for assessing emotional and psychological outcomes in technology-mediated environments.

- **Loneliness :** Loneliness was measured using the UCLA Loneliness Scale (Version 3), a widely validated self-report instrument that assesses subjective feelings of social isolation and lack of companionship. The scale consists of 20 items rated on a four-point Likert scale ranging from "Never" to "Often." Higher scores indicate greater perceived loneliness. This instrument was chosen due to its strong internal consistency (Cronbach's $\alpha > 0.85$) and extensive use in psychological and human–computer interaction research contexts.

- **Psychological Well-being :** Well-being was assessed using the World Health Organization Five Well-Being Index (WHO-5), which evaluates positive mood, vitality, and general interest in life over the past two weeks. The WHO-5 includes five positively worded items rated on a six-point Likert scale from "At no time" to "All of the time." Total scores were multiplied by four to yield a percentage scale from 0 to 100, where higher scores indicate better psychological well-being. The WHO-5 has demonstrated excellent validity as a short global measure of subjective well-being and is frequently applied in mental health and digital intervention studies.
- **Perceived Empathy and User Satisfaction :** Participants' perceptions of the chatbot's empathy and their overall satisfaction with the interaction were measured using adapted scales from previous chatbot and affective computing studies. The Perceived Empathy Scale assessed the extent to which users felt understood, emotionally supported, and acknowledged by the chatbot. Meanwhile, the chatbot satisfaction questionnaire including evaluated ease of use, usefulness, and enjoyment of interaction. Each construct was measured using a five-point likert scale 1 = Strongly Disagree to 5 = Strongly Agree. Both scales have been shown to possess high construct reliability ($\alpha > 0.80$) and predictive validity in prior research on affective human AI communication.

All instruments were administered at both the pre-test and post-test phases to evaluate changes in participants' psychological states and perceptions following the chatbot interactions. The use of well-established measures not only strengthens the methodological rigor of the study but also enables meaningful comparison with existing research in the domains of affective computing and digital mental health.

Table 1. Operationalization of Research Variables

Variable Type	**Variable**	**Definition**	**Indicator**	**Measurement Instrument**
Independent Variable (IV)	Sentiment-aware chatbot interaction	Interaction with a chatbot enhanced with NLP and sentiment analysis to recognize and respond to user	1. Accuracy of sentiment detection 2. Contextual appropriateness of responses 3. Frequency of empathetic responses	System log analysis, user perception questionnaire
Dependent Variable (DV1)	Loneliness reduction	Decrease in subjective feelings of social isolation and disconnection	1. Emotional connectedness 2. Frequency of loneliness thoughts 3. Perceived social support	UCLA Loneliness Scale (Version 3)
Dependent Variable (DV2)	Psychological well-being	Positive evaluation of one's mental health state	1. Positive mood 2. Relaxation and energy 3. Life satisfaction	WHO-5 Well-Being Index
Mediator (M1)	Perceived empathy	User's perception of the chatbot's ability to understand and respond to emotions	1. Emotional understanding 2. Warmth of response 3. Human-like empathy	Adapted Perceived Empathy Scale
Mediator (M2)	User satisfaction	User's evaluation of the interaction quality with the chatbot	1. Ease of use 2. Usefulness 3. Engagement satisfaction	Adapted Chatbot Satisfaction Questionnaire

As illustrated in Table 1, the independent variable in this study is the sentiment-aware chatbot interaction, operationalized through system logs and user perception of empathetic responses. The dependent variables focus on loneliness reduction and psychological well-being, measured through well-established instruments such as the UCLA Loneliness Scale and the WHO-5 Well-Being Index. Furthermore, perceived empathy and user satisfaction are positioned as mediating variables, reflecting the quality of the user's interaction with the chatbot. The use of validated psychometric tools ensures the reliability and validity of measurement, while the

inclusion of mediators allows for a more comprehensive understanding of how sentiment-aware responses influence user outcomes. This operational framework thus provides a structured foundation for hypothesis testing and statistical analysis in the subsequent sections.

3.5. Data Analysis

Data were analyzed using both descriptive and inferential statistical techniques to ensure a comprehensive understanding of the results. All statistical analyses were conducted using SPSS and AMOS software packages. Initially, descriptive statistics were calculated to summarize demographic information, including age, gender, and prior experience with AI-driven applications. This step provided an overview of participant characteristics and helped ensure the comparability of the control and experimental groups. Data screening was also performed to assess normality, homogeneity of variance, and the presence of outliers, ensuring that the assumptions required for subsequent parametric tests were met.

To evaluate the impact of the sentiment-aware chatbot intervention, paired-sample t-tests were performed to compare pretest and posttest scores within each group. This analysis aimed to identify whether participants experienced significant changes in loneliness and psychological well-being after interacting with the chatbot. Subsequently, a one-way ANOVA was used to test mean differences between the control and experimental groups, providing insight into the relative effectiveness of the sentiment-aware chatbot compared to a conventional chatbot. Post-hoc tests were applied where necessary to further examine specific group differences.

Beyond basic statistical comparisons, Structural Equation Modeling (SEM) was employed to test the hypothesized relationships between variables and to evaluate the mediating roles of perceived empathy and user satisfaction. SEM was chosen due to its capability to simultaneously estimate multiple dependent relationships and to assess both direct and indirect effects among constructs. The model was evaluated using several goodness of fit indices, including the Comparative Fit Index (CFI), Tucker Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA), and Standardized Root Mean Square Residual (SRMR). An acceptable model fit was indicated by CFI and TLI values above 0.90, RMSEA values below 0.08, and SRMR values below 0.10. This multi-level analytical approach provided a robust framework for testing the study's hypotheses. The combination of traditional inferential methods and Structural Equation Modeling (SEM) provided a solid basis for validating both direct and indirect relationships among variables.

4. RESULT AND DISCUSSION

This section presents and discusses the findings of the study based on the data collected from the experimental and control groups. The primary objective of this analysis is to evaluate the effectiveness of the sentiment-aware chatbot in reducing loneliness and enhancing psychological well-being. Quantitative data were analyzed using statistical methods to determine significant differences between pre-test and post-test scores, while structural modeling was employed to examine the mediating effects of perceived empathy and user satisfaction.

The discussion integrates both quantitative outcomes and theoretical interpretation, linking the empirical results with existing literature in affective and positive computing. By doing so, this section aims to provide a comprehensive understanding of how sentiment-aware chatbots contribute to emotional well-being through empathetic and adaptive interactions. The presentation of results is divided into two main parts: the first subsection highlights the quantitative results obtained through statistical testing, and the second focuses on the interpretative discussion of the findings, situating them within broader psychological and technological contexts.

4.1. Quantitative Results

The quantitative analysis revealed that participants in the experimental group who engaged with the sentiment-aware chatbot reported a statistically significant decrease in loneliness scores compared to the control group. Using the UCLA Loneliness Scale, the average loneliness score in the experimental group decreased from 55.5 (pre-test) to 48.1 (post-test) ($p < 0.01$), while the control group showed no significant change, moving from 55.2 54.8 ($p > 0.05$). As shown in Table 2, this indicates that the intervention effectively reduced feelings of loneliness among participants who interacted with the sentiment-aware chatbot.

The mean difference of –7.4 points in the experimental group demonstrates the substantial impact of the chatbot's affective capabilities on emotional well-being. The integration of sentiment-awareness allowed

the chatbot to respond empathetically, thereby enhancing users' sense of social presence and connectedness. In contrast, the control group, which interacted with a standard chatbot, showed only a minimal and non-significant reduction of –0.4 points ($p = 0.42$). These findings underscore the importance of incorporating emotional intelligence features in conversational agents to promote mental health and reduce loneliness through compassionate digital interaction.

Table 2. Comparison of Loneliness Scores (UCLA Scale)

Group	**N**	**Pre-test Mean (SD)**	**Post-test Mean (SD)**	**Mean Difference**	**p-value**
Experimental	75	55.5 (8.4)	48.1 (7.2)	-7.4	$<$ **0.01**
Control	75	55.2 (8.0)	54.8 (7.9)	-0.4	0.42

As shown in Table 2, participants in the experimental group experienced a significant reduction in loneliness scores after interacting with the sentiment-aware chatbot. The mean score decreased from 55.5 to 48.1, indicating a substantial improvement in perceived social connectedness ($p < 0.01$). Conversely, the control group showed no significant change between pre-test and post-test scores (55.2 to 54.8, $p > 0.05$). These findings suggest that the sentiment-aware chatbot was effective in mitigating loneliness, while conventional chatbots failed to produce notable improvements. These findings suggest that the sentiment-aware chatbot was effective in mitigating loneliness, while conventional chatbots failed to produce notable improvements.

Similarly, psychological well-being scores measured through the WHO-5 Index improved significantly for the experimental group, increasing from 37.9 (pre-test) to 46.7 (post-test) ($p < 0.01$). In contrast, the control group exhibited a slight but non-significant increase (38.6 to 39.2). These findings provide quantitative evidence supporting the hypotheses that sentiment-aware chatbots contribute to reducing loneliness and improving well-being.

Structural Equation Modeling (SEM) further demonstrated that perceived empathy and user satisfaction functioned as mediators between chatbot interaction and outcome variables. Perceived empathy was found to significantly mediate the effect of sentiment-aware interaction on loneliness reduction, while user satisfaction more strongly mediated the relationship with psychological well-being. These results validate the hypothesized model (H1–H8), underscoring the importance of empathy and satisfaction in shaping user experiences with chatbots.

Table 3. Structural Equation Modeling (SEM) Results

Path	**Standardized β**	**t-value**	**p-value**	**Result**
Sentiment-aware $\rightarrow$ Perceived Empathy	0.64	9.25	< 0.001	Supported
Sentiment-aware $\rightarrow$ User Satisfaction	0.58	8.47	< 0.001	Supported
Perceived Empathy $\rightarrow$ Loneliness Reduction	0.41	7.18	< 0.001	Supported
User Satisfaction $\rightarrow$ Psychological Well-being	0.49	8.03	< 0.001	Supported

As shown in Table 3, all hypothesized paths in the Structural Equation Modeling (SEM) were statistically significant, indicating strong relationships among the studied variables. The standardized β values ranged from 0.41 to 0.64, suggesting moderate to strong effects. Specifically, the sentiment-aware interaction demonstrated a substantial positive influence on perceived empathy ($\beta = 0.64$, $p < 0.001$) and user satisfaction ($\beta = 0.58$, $p < 0.001$). Furthermore, perceived empathy significantly contributed to loneliness reduction ($\beta = 0.41$, $p < 0.001$), while user satisfaction positively affected psychological well-being ($\beta = 0.49$, $p < 0.001$). These findings confirm that perceived empathy and user satisfaction play crucial mediating roles in enhancing users' psychological outcomes within sentiment-aware systems, emphasizing the importance of emotionally intelligent design in digital interaction platforms.

5. DISCUSSION

The findings confirm that sentiment-aware chatbots are more effective than conventional chatbots in addressing loneliness and supporting psychological well-being. Participants who interacted with the sentiment-aware chatbot demonstrated a statistically significant reduction in loneliness scores and an improvement in emotional well-being indicators. These outcomes suggest that the integration of sentiment recognition and affective response mechanisms enables chatbots to engage users in more human-like and emotionally supportive interactions. Such findings align with prior studies in affective and positive computing, which emphasize

that empathetic digital companions can strengthen psychological resilience, enhance perceived social support, and mitigate feelings of isolation [33]. The present results extend this evidence by demonstrating that affect-aware responses not only influence short-term mood but also promote sustained engagement, contributing to long-term well-being outcomes.

The mediating role of perceived empathy and user satisfaction further underscores the importance of the emotional dimension in human AI interaction. Statistical modeling revealed that empathy and satisfaction act as significant mediators between sentiment-aware chatbot engagement and psychological benefits. This indicates that technological sophistication alone such as advanced algorith

6. MANAGERIAL IMPLICATIONS

The findings of this study provide several important implications for practitioners, organizations, and policymakers seeking to address loneliness and promote psychological well-being through technological interventions. For technology developers and AI companies, the results highlight the necessity of integrating sentiment analysis and empathy-driven response mechanisms into chatbot design. Unlike conventional conversational agents, sentiment-aware chatbots demonstrated measurable effectiveness in reducing loneliness and improving user well-being, indicating that organizations developing digital health and wellness solutions should prioritize affective computing features as core design principles rather than optional enhancements.

For healthcare providers and mental health institutions, the study suggests that sentiment-aware chatbots can serve as scalable, low-cost, and accessible companions to support patients experiencing social isolation. These systems could complement existing therapeutic practices by providing continuous, empathetic interactions, particularly in resource-constrained settings where access to mental health professionals is limited. Similarly, for educational institutions, particularly universities and online learning platforms, the integration of sentiment-aware chatbots offers a promising approach to support students facing loneliness in remote or hybrid learning environments. By providing emotionally responsive digital companions, institutions can foster a greater sense of social connection and enhance overall student well-being.

For policymakers, the findings underline the potential role of sentiment-aware AI in national and community based mental health strategies. Investing in the development and deployment of such technologies could reduce the societal burden of loneliness and mental health disorders, aligning with public health goals to promote resilience and holistic well-being. In conclusion, sentiment-aware chatbots should not be viewed merely as technological tools but as strategic assets that can enhance human connection, support mental health, and contribute to broader societal well-being. Managers and decision-makers who embrace this innovation can gain both social impact and competitive advantage by aligning their initiatives with the principles of positive computing and compassionate AI.

7. CONCLUSION

This study provides strong evidence that sentiment-aware chatbots can serve as effective digital companions for reducing loneliness and enhancing psychological well-being. By integrating principles from affective and positive computing, these chatbots are able to detect emotional cues, generate empathetic responses, and adaptively engage with users, leading to measurable improvements in emotional resilience and a reduction in subjective feelings of social isolation. The findings confirm that technological sophistication alone is insufficient the emotional quality of interactions, including perceived empathy and user satisfaction, plays a critical role in realizing meaningful psychological benefits. The results of this research demonstrate that sentiment-aware chatbots offer a scalable and low-cost solution to complement existing mental health interventions. In particular, these digital companions can provide continuous emotional support in settings where human resources are limited, such as for students in remote learning environments, older adults facing social isolation, or populations in urban areas with restricted access to mental health services. The study highlights that chatbots designed with affective and positive computing features can foster a sense of companionship, improve user satisfaction, and ultimately contribute to the broader goal of enhancing psychological well-being.

Despite these promising outcomes, the study has several limitations that point toward future research directions. The participant pool was predominantly composed of students and young adults, which limits the generalizability of the findings to other demographic groups, such as older adults or individuals experiencing chronic loneliness. Additionally, the six-week intervention period may not capture long-term behavioral or emotional changes, and the chatbot's ability to handle complex or culturally nuanced interactions remains

limited. These limitations underscore the need for future studies to adopt more diverse participant samples, extended intervention periods, and more advanced adaptive dialogue systems.

Future research should also explore the integration of sentiment-aware chatbots with other mental health and social support interventions to examine potential synergistic effects. Longitudinal studies can provide insights into the sustainability of chatbot-mediated reductions in loneliness and improvements in well-being. Moreover, investigating the impact of culturally sensitive and personalized chatbot responses can enhance user engagement and emotional accuracy, allowing these systems to better serve heterogeneous populations across different social and cultural contexts. Overall, sentiment-aware chatbots represent a significant advancement at the intersection of technology and human-centered design. They are not merely tools for conversation but strategic assets capable of promoting social connection, mental health, and holistic well-being. Continued research and development in this area, focusing on inclusivity, emotional nuance, and long-term effectiveness, can ensure that these AI systems remain empathetic, adaptive, and impactful, aligning with broader societal goals of resilience, happiness, and compassionate technology use.

8. DECLARATIONS

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Conceptualization: EA; Methodology: JE; Software: MB; Validation: SK and HN; Formal Analysis: SK and MB; Investigation: EA; Resources: HN; Data Curation: JE; Writing Original Draft Preparation: SK and HN; Writing Review and Editing: EA and JE; Visualization: MB; All authors, HN, SK, MB, EA, and JE, have read and agreed to the published version of the manuscript.

8.3. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

8.4. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

8.5. Declaration of Conflicting Interest

The authors declare that they have no conflicts of interest, known competing financial interests, or personal relationships that could have influenced the work reported in this paper.

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