



# Alexa as an Active Listener: How Backchanneling Can Elicit Self-Disclosure and Promote User Experience

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Active listening is a well-known skill applied in human communication to build intimacy and elicit self-disclosure to support a wide variety of cooperative tasks. When applied to conversational UIs, active listening from machines can also elicit greater self-disclosure by signaling to the users that they are being heard, which can have positive outcomes. However, it takes considerable engineering effort and training to embed active listening skills in machines at scale, given the need to personalize active-listening cues to individual users and their specific utterances. A more generic solution is needed given the increasing use of conversational agents, especially by the growing number of socially isolated individuals. With this in mind, we developed an Amazon Alexa skill that provides privacy-preserving and pseudo-random backchanneling to indicate active listening. User study (N = 40) data show that backchanneling improves perceived degree of active listening by smart speakers. It also results in more emotional disclosure, with participants using more positive words. Perception of smart speakers as active listeners is positively associated with perceived emotional support. Interview data corroborate the feasibility of using smart speakers to provide emotional support. These findings have important implications for smart speaker interaction design in several domains of cooperative work and social computing.

CCS Concepts: • **Human-centered computing** → **Interaction design theory, concepts and paradigms**; *Personal digital assistants*; • **Applied computing** → **Consumer health**.

Additional Key Words and Phrases: smart speaker, voice user interface, attentive listening, eHealth

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## 1 INTRODUCTION

Active listening is a much-touted communication technique to convey one's engagement in a given interaction, stimulate turn-taking and promote self-disclosure [30, 35, 42, 51, 79]. While there are many similar techniques and alternative terms, including empathic, attentive and supportive listening, the essence of active listening comes from exhibiting unconditional attention to the

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speakers and confirmation of their experiences by utilizing certain responses such as verbal and nonverbal acknowledgment, paraphrasing, and asking disclosure-enhancing questions [79]. By demonstrating various active listening skills, from generic (e.g., nodding and vocalizations) to specific (e.g., wincing or exclaiming), listeners serve as co-narrators by encouraging and influencing story telling from narrators [6].

Active listening by itself can be a form of therapy and support in both informal [10, 42] and formal clinical settings [31, 39]. One mechanism by which active listening can help cope with stress and emotional episodes is through self-disclosure [30, 51]. Active listening is found to effectively elicit disclosure of feelings and personal thoughts [30, 51], and such “social sharing of emotion” [69] can lead to emotional recovery and distress reduction [68], thereby improving psychological wellbeing [57].

However, for active listening to be effective, it requires more than simply paying attention: active listening requires considerable effort and training [70]. While informal connections (e.g., family members) can provide support for self-disclosure, they might not have the necessary and consistent active listening skills to maximize emotional and psychological benefits [42]. Furthermore, exposure to others’ emotional episodes can potentially impact listeners’ own wellbeing [55, 66]. These issues can make it difficult for individuals in need to find adequate support to engage in self-disclosure behaviors in their day-to-day lives, which is particularly true for socially isolated individuals.

As an alternative to human listeners, we can leverage smart speakers with voice-based user interface (VUI) to support individuals to engage in effective disclosure in the real world. Smart speakers have seen a significant recent rise in adoption and ownership. In 2021, 94 million individuals in the US were estimated to own at least one smart speaker [1]. The voice interfaces in these devices allow users to conduct a wide range of tasks. For example, users can perform search queries, get weather updates, and control appliances by “talking” to these devices. This project aims to extend the current capabilities of smart speakers to act as active listeners that can support self-disclosure.

Then, how can we make smart speakers to become active listeners? Active listening requires providing acknowledgment and avoiding interruptions to encourage individuals to elaborate and engage in disclosure over multi-turn dialogues [34]. Verbal continuers or backchanneling cues (e.g., “hm”, “ahm”, and “yes”) can convey acknowledgment during conversations and thus, is an important element of active listening [34]. A timely backchanneling cue coming from a dialogue system can be enough to render users into thinking that the automated backchanneling responses came from a human counterpart [77]. Backchanneling cues have also been shown to support narrative development during a conversation with a spoken dialog system [38, 58]. Specifically in the context of smart-speaker interactions, Cohn et al. [16] reported that systematically providing backchanneling cues to specific responses from an Alexa chatbot (i.e., fillers, such as “um”, “mhhh”) as well as emotionally expressive interjections that signal interest (e.g., “Awesome”, “Cool”) and express acceptance and agreement (e.g., “Okey dokey!”, “High Five!”) can enhance overall user rating of the interaction. This suggests that we can incorporate backchanneling cues in smart speakers to indicate active listening, which can subsequently lead to better support for user interactions, including self-disclosure.

Yet, designing smart speakers to deliver backchanneling cues poses a number of technical challenges. Current smart speakers do not provide meaningful backchanneling cues to support narrative development, which is essential for effective disclosure. Instead, smart speakers are optimized for quick turn-taking and short verbal commands. Backchanneling also depends on context, flexible turn-taking, and timing of utterances. For instance, randomizing the backchanneling cues and switching backchanneling types (interchanging nodding and vocalized backchanneling) can reduce the human-likeness of an embodied virtual agent (compared to adhering to a human-created backchanneling cadence and type) [60]. However, offering context-aware backchanneling

requires interpreting social cues and understanding natural language in real time, which can be highly challenging, especially given the absence of human-like embodied cues in smart speakers.

Furthermore, computational limitations of smart speakers require offloading data processing steps to the cloud. This can raise serious privacy concerns in certain use cases, specifically when individuals might engage in potentially sensitive self-disclosure. For example, Lala et al. [45] proposed the use of prosodic and content (e.g., focus word) features to deliver backchanneling. However, uploading and processing such features from self-disclosure in the cloud can result in considerable privacy, legal, and ethical challenges. As such, the key issue that we need to address before we can use smart speakers to support self-disclosure is this: *how can we transform smart speakers into active listeners by providing verbal acknowledgments while minimizing privacy risks?*

We address this issue by delivering pseudo-random backchanneling instead of providing cues that are contingent upon the content of users' commands and disclosures. To this end, we developed an Amazon Alexa app ("skill") that delivers random backchanneling cues at pre-determined intervals as users engage with it. This system does not aim to be context-specific and as such, there is no need to store or process self-disclosure content. This considerably lowers privacy and security risks. We conducted a user study (N = 40) to evaluate the developed system. In the following sections, we describe the hypotheses guiding the study, as well as details of the methods used and findings emerging from statistical analyses of quantitative data and thematic analysis of qualitative data. We then discuss the implications of our findings to designing more privacy-sensitive and trustworthy VUIs and the applications of smart speaker technologies for therapeutic support. This study can help to extend the discussion within the CSCW community on social and collaborative user interactions with smart speakers, beyond supporting group interaction among users [62, 63], by examining the potential of human-to-smart-speaker collaboration in support of both individuals' and others' (e.g., family members, caretakers, counselors) wellbeing. This study also expands previous CSCW studies focused on the use of conversational agents for stress-related disclosure [72] and self-guided stress coping [37].

## 2 BACKGROUND AND RELATED WORK

Active listening has been studied as a major component in counseling [18], as a therapeutic skill that makes clients feel heard by the correspondent listening attentively and responding empathically [47]. It conveys immediate processing of information and decision making [71]. While there are several active listening tactics such as paraphrasing and asking questions [79], even the simplest verbal cues like backchanneling can have a significant impact on how others respond. In particular, Gardner [23] explained that such seemingly meaningless verbal cues actually imbue subtle and complex meanings into conversations as they help to co-create the narrative with other speakers. In the context of telephone counseling, Danby et al. [18] studied the role of backchanneling where counselors used minimal responses in the form of verbal acknowledgments and continuers (e.g., okay, mm hm, right) to encourage clients to talk. This listening behavior resulted in increased turn taking and decreased ambiguity compared to web-counseling through instant messaging [18]. Such elicitation of disclosure is in fact a very important element of active listening that helps individuals cope with stress and emotional distress [30, 51].

Sharing of emotional experiences is a common practice across different populations and cultures [67]. Such disclosure — writing or talking about upsetting events — can lead to psychological and physical health improvements [22]. Recent studies have proposed a number of theoretical models to explain positive effects of disclosure on health and wellbeing. For example, Sloan and Marx [74] discussed how cognitive adaptation, disinhibition, and repeated exposure enabled by disclosure can lead to better processing of emotional events. Rimé [67] also pointed out the socio-affective benefit of disclosure. Irrespective of the underlying mechanism, disclosure has been widely and successfully

used as an intervention tool. Focusing on written disclosure, Pennebaker [59] introduced expressive writing as a therapeutic process to address trauma. He found that increased use of insight, causal, and cognitive words in written disclosure is linked to health improvements. Expressive writing has been used to provide emotional support for individuals with mood disorder [4], depression [40], post-traumatic stress disorder (PTSD) [12], and breast cancer [17].

While recent disclosure studies have mostly focused on writing, verbal disclosure has also been shown to improve health and wellbeing [57]. Indeed, Fattarolli [22] argued that speaking may be superior to writing as it is easier and demands fewer cognitive resources. Furthermore, speaking might also allow more complex disclosure through both verbal and non-verbal (e.g., facial) expressions. The interactive nature of verbal disclosure requires two actors – a major speaker and a listener – to construct the narrative and maintain engagement. The outcome of verbal disclosure depends on listeners' reactions [67] – active listening leads to effective disclosure.

A number of recent studies have focused on developing technologies that can increase engagement by serving as active listeners. Johansson et al. [33] developed a social robot that incorporates listening cues in its responses when asking users to disclose their travel memories. Their study explores the process of developing a dialogue system and a response model that allows a robot to act as an active listener. Similarly, DeVault [19] developed an embodied virtual agent called Semi Sensei Kiosk that demonstrates empathic listening behavior using verbal continuers to engage in small talk with patients who have PTSD or depression. Lala et al. [45] developed Erica – an embodied bot for the elderly to maintain communication abilities. Their system not only uses backchanneling to show interest and engage with the user, but also produces context-specific responses and aims to support appropriate turn-taking behaviors.

Such development efforts stem from the fact that technologies can act as effective agents to elicit self-disclosure from users. For instance, Ho et al. [28] compared the effects of written emotional disclosure to a chatbot vs. a human partner, and found that both produce similar psychological benefits. Regardless of agent (i.e., chatbot vs. human), users were found to make more intimate disclosures when they engaged in emotional (vs. factual) conversations, which in turn, created positive emotional and relational outcomes [28]. It seems that adding certain interaction cues based on human communication principles can encourage users' self-disclosure to machines. Relevant to this point, Moon [52] found that when computers revealed intimate information first and followed socially appropriate sequence of disclosure (i.e., gradual disclosure from superficial to intimate), users became more comfortable making intimate self-disclosure, just as in human-to-human communication. Moving from computers, Lee et al. [46] found that reciprocal self-disclosure from chatbots also elicited more disclosure from users. Liu and Sundar [48] reported that when a chatbot expressed sympathy or empathy, it was perceived as being more understanding and supportive. Jeong et al. [32] found that the use of "conversational fillers" by conversational agents made them more entertaining for socially oriented interactions.

Together, this body of research suggests active listening by non-human agents or bots could indeed be psychologically significant, affecting disclosure and subsequent emotional state. Extending those findings into the context of smart speakers, we hypothesize that active listening signaled by backchanneling cues coming from the smart speaker can exert positive effects on three aspects of emotional and behavioral outcomes: (a) change in emotional states, (b) perceived emotional support, and (c) self-disclosure behaviors (H2). However, for such effects to occur, a prerequisite condition is that users need to recognize a smart speaker with backchanneling cues as an active listener (H1). Nass and Lee [54] label such recognition (e.g., identification and classification) of social characteristics of computers (or non-human objects) as "first-degree social response", triggering which can lead to more applied attitudinal and behavioral changes among users (i.e., "second-degree social response"). Following this rationale, we test both first-degree (H1) and second-degree (H2)

social responses from users, focused on smart speaker backchanneling effects. In addition, we examine this cascading effect of recognition (first-degree) to application (second-degree) regarding users' socialization with smart speakers by testing the mediating role of active listening perception in the backchanneling effect on user outcomes (H3). In doing so, this study can help shed light on one of the underlying theoretical mechanisms that explains users' social responses to smart speakers. Overall, this paper focuses on the following hypotheses:

- **H1:** Backchanneling cues will positively affect users' perception of a smart speaker as an active listener (i.e., active listening perception).
- **H2:** Backchanneling cues will have positive effects on users' (a) emotional state, (b) perceived emotional support, and (c) self-disclosure behaviors.
- **H3:** Active listening perception will mediate the effects of backchanneling cues on positive outcomes predicted by H2.

Furthermore, beyond promoting emotional support and self-disclosure, we explored if the above outcomes will eventually lead to a better user experience. In particular, by incorporating pseudo-random backchanneling cues, we not only test if backchanneling from smart speakers can effectively deliver active-listening benefits, but also if it can be provided in a privacy-preserving yet user-friendly manner, leading to the following research question:

- **RQ1:** Will the hypothesized positive effects of backchanneling eventually lead to improved usability of the smart speakers?

### 3 METHOD

To determine the effects of pseudo-random backchanneling, this study employed a between-subjects experiment design with 2 conditions — backchanneling vs. control. Participants in these conditions interacted with different Alexa skills. They were not aware of the difference between the control and backchanneling conditions assigned to them, nor aware of the purpose of our study. During the study, we collected audio recordings of participants' interactions with Alexa using a separate audio recorder. We recruited 40 participants from a large public university in the United States and assigned them to one of the two conditions. The gender distribution of the participants was even with 20 males and 20 females (see Table 1 for individual participant information). Only half of the participants mentioned that English was their first language, but all participants were able to understand the study procedure and interact with Alexa fluently in English. Of the 40 participants, 24 participants (60%) stated that they currently use smart speaker assistants (14 infrequent users and 10 regular users), and 15 users reported to not use smart speaker assistant at the time of data collection.

#### 3.1 Procedures

During the study, participants first provided consent and then rated their current emotional state through an online questionnaire, which served as our pre-test measure. After that, they were instructed to interact with Alexa to express their thoughts regarding certain personal life matters. The skills asked users to answer 4 questions: two questions related to professional life regarding time management and weekly goals, and two questions regarding personal life choices and relationships (see the supplementary document for the questions used for the user interaction with Alexa). We incorporated specific questions in the study since our pilot data showed that some participants have difficulty in coming up with topics to interact with Alexa.

To control for the order effect of question type, half the participants in each condition were asked the professional questions first and the other half were asked the personal life and relationship questions first. Participants were not interrupted by the researcher during the study. To provide

ID	Age	Gender	Native in English	Education	Smart Speaker Use
P1	21-24	Female	Yes	College Student	Yes, regularly
P2	21-24	Female	No	College Student	Yes, regularly
P3	18-20	Male	Yes	College Student	No
P4	18-20	Male	Yes	College Student	No
P5	31-34	Female	No	Graduate Student	Yes, regularly
P6	18-20	Male	Yes	College Student	Yes, but not often
P7	35-40	Female	Yes	College Alumna	Yes, but not often
P8	25-30	Male	No	Graduate Student	Yes, regularly
P9	25-30	Female	No	Post-graduate	Yes, regularly
P10	25-30	Male	Yes	Graduate Student	No
P11	25-30	Male	No	Graduate Student	Yes, but not often
P12	31-34	Male	No	Graduate Student	Yes, regularly
P13	31-34	Female	No	College Alumna	Yes, regularly
P14	25-30	Male	No	Graduate Student	Yes, regularly
P15	21-24	Male	No	College Student	Yes, but not often
P16	25-30	Female	No	Graduate Student	No
P17	31-34	Male	Yes	Post-graduate	Yes, but not often
P18	25-30	Male	No	Graduate Student	Yes, but not often
P19	25-30	Female	No	Graduate Student	Yes, but not often
P20	Older than 50	Female	Yes	College Alumna	Yes, regularly
P21	31-34	Female	No	Graduate Student	No
P22	18-20	Female	Yes	College Student	Yes, but not often
P23	Older than 50	Female	Yes	Post-graduate	Yes, regularly
P24	25-30	Male	Yes	Graduate Student	Yes, but not often
P25	25-30	Female	Yes	Graduate Student	No
P26	25-30	Female	No	College Student	Yes, but not often
P27	25-30	Male	No	Graduate Student	Yes, regularly
P28	21-24	Male	Yes	Graduate Student	Yes, but not often
P29	18-20	Female	Yes	College Student	Yes, regularly
P30	21-24	Female	No	Graduate Student	No
P31	25-30	Male	No	Graduate Student	Yes, but not often
P32	25-30	Male	No	Graduate Student	No
P33	25-30	Male	No	Graduate Student	Yes, but not often
P34	25-30	Male	No	Graduate Student	Yes, but not often
P35	25-30	Female	Yes	College Student	Yes, regularly
P36	21-24	Female	Yes	College Alumna	Yes, regularly
P37	25-30	Female	Yes	College Alumna	Yes, regularly
P38	35-40	Male	Yes	Post-graduate	No
P39	25-30	Male	Yes	Graduate Student	No
P40	Older than 50	Female	Yes	College Alumna	Yes, regularly

Table 1. Participant information

a sense of privacy, the researcher left the room as participants interacted with Alexa. Since the Alexa skill we used for this study did not record any of the user comments (as described in the next

section), we used a separate device to record users’ interactions with Alexa, which were manually transcribed later for text analysis.

After their interactions with Alexa, participants completed an online questionnaire with questions related to the outcome variables of interest and demographic information. In addition, they went through a semi-structured interview regarding their experiences, expectations, and ideas for the future of smart speakers for mental health. Upon completion, participants were compensated \$10 for their time. The research protocol was approved by the Institutional Review Board (IRB) from the researchers’ institution at the time of data collection. All of the participants were informed that the entire study session will be recorded for analysis, and offered consent prior to participation. We did not physically disable the microphone as the rest of study session required functional interactions with Alexa. However, the skill did not collect any responses as the participants were speaking about their personal experiences.

### 3.2 Manipulation and Alexa Skill Development

For the manipulation of the independent variable (i.e., active listening vs. control), we developed two different sets of Alexa skills. While skills for both conditions asked users to respond to four questions as mentioned above, only the active listening condition provided pseudo-random verbal continuers such as “hm,” “yeah,” “go on,” and “I see”. No such cues were added to the Alexa skill developed for the control condition.

When developing the Alexa skill, we initially leveraged the Amazon Alexa framework to deliver context-specific backchanneling cues to users. For example, we conducted sentiment analysis to deliver appropriate continuers (e.g., responding “I am sorry to hear that” to a negative event mentioned by the participant), and developed a number of prototypes and conducted evaluation over time. However, given the current limitations of Alexa API, delivering fully responsive and context-specific backchanneling cues turned out to be unfeasible. Specifically, the Amazon Alexa ecosystem is optimized for short sentences. The devices also have limited processing capabilities and offload bulk of their data handling to the cloud. This causes significant delay in processing multi-sentence user inputs. In other words, network and processing delays make it impractical to deliver dynamic backchanneling cues in a time-appropriate manner. Other smart speaker platforms have similar limitations. Furthermore, context-specific backchanneling requires speech content processing, which can have serious privacy issues. Given these limitations, we instead focused on a context-independent way of providing backchanneling cues. That is, instead of performing prosodic and content feature analysis to identify end of utterance and context, we decided to deliver pseudo-random backchanneling cues at pre-determined intervals. Thus, we note that the Alexa skill we developed and used for this study were not able to listen, understand, nor detect user speech content.

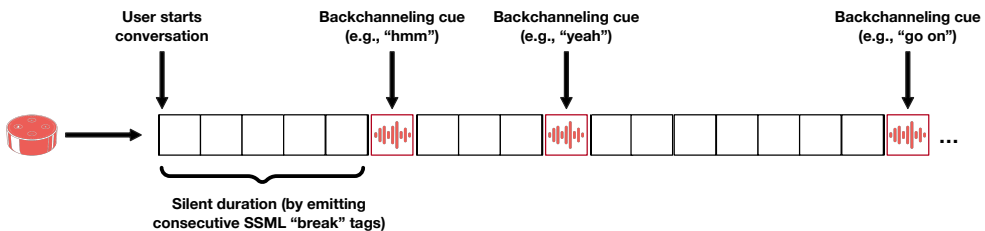


Fig. 1. We used Speech Synthesis Markup Language (SSML) [2] to embed backchanneling cues during user interaction for the active listening condition.

For implementation, we used the Amazon Alexa framework (see Figure 1). For generating pauses (silent durations), we used the “break” tag in Speech Synthesis Markup Language (SSML) [2] supported by Alexa. The duration of the pauses ranged between 7 to 50 seconds. These pause durations were selected based on pilot data [53] to minimize user interruptions. Given that a “break” tag can have 10 seconds of silence at most, we incorporated multiple “break” tags whenever necessary. After a pause, Alexa delivered a backchanneling cue. We ensured that all consecutive backchanneling cues were different. To avoid interrupting users, we also used lower volume for backchanneling cues (by using the parameter “soft” for volume in the “prosody” SSML tag). During the study session, we did not record any user responses using Alexa. This allowed us to avoid potential privacy concerns.

### 3.3 Measurements

**3.3.1 Perception of active listening.** We adapted the Active-Empathic Listening scale from Gearhart and Bodie [25] to assess perceived active listening by Alexa (e.g., “Alexa was sensitive to what I was saying;” “Alexa seemed to listen to me for more than just spoken words;” “Alexa delivered a sense of agreement for what I was saying when appropriate;” 10-point Likert scale;  $M = 3.23$ ,  $SD = 1.93$ ,  $\alpha = .94$ ).

**3.3.2 Emotional states.** To evaluate change in users’ emotions after interacting with Alexa, we administered two questionnaires: once before (pre-emotion) and another after (post-emotion) the interaction with Alexa. Following Watson et al. [78], participants were asked to rate their current emotional state on the following 10 affective adjectives: active, calm, content, enthusiastic, happy, angry, anxious, embarrassed, nervous, and sad. Five of these adjectives indicate positive emotions, and other five adjectives indicate negative emotions. These ratings were measured on a 10-point Likert scale (see Table 2).

**3.3.3 Perceived emotional support from Alexa.** We revised 6 items from Clark et al. [15], originally designed to measure the effectiveness of comforting messages from friends, to fit the context of interaction with Alexa (e.g., “Alexa made me feel better about myself;” “After talking with the Alexa, I feel less depressed;” “Talking with Alexa helped me get my mind off the negative experience” 10-point Likert scale;  $M = 5.12$ ,  $SD = 2.10$ ;  $\alpha = .94$ ).

**3.3.4 Users’ self-disclosure behaviors.** Self-disclosure behaviors of users were measured in both the amount of self-expression (by counting (1) time spent and (2) words used in interaction with Alexa) as well as emotional expression (by identifying the proportion of (3) positive and (4) negative emotional word usage). These behavioral measures were obtained from the audio recordings of the interaction. In particular, the length of the audio interaction represented (1) time spent on the interaction ( $M = 346.49$  seconds,  $SD = 153.18$ ). Following Balon and Rimé [5], we used LIWC (Linguistic Inquiry and Word Count) [76] to perform lexical analysis. This included calculating word count ( $M = 672.03$  words,  $SD = 339.10$ ), and the proportion of the use of positive ( $M = 2.20\%$ ,  $SD = 1.05$ ) and negative ( $M = 0.55\%$ ,  $SD = 0.44$ ) emotional words. Due to technical issues, we were not able to extract audio recording of one participant’s interaction. We also asked about demographics (e.g., language skills) and media usage patterns in our questionnaire <sup>1</sup>.

**3.3.5 Perceived usability of the Alexa skill.** Participants were asked to evaluate the quality of the Alexa skill based on the following 11 adjectives: good, useful, high quality, user-friendly, coherent, organized, pleasant, entertaining, appealing, intelligent, smart; ( $M = 6.09$ ,  $SD = 2.18$ ,  $\alpha = .96$ ). Those items were adapted from previous research to measure attitudes toward web services related to

<sup>1</sup>We have uploaded the surveys and questionnaires used in the study as supplementary documents.



usability [36, 75], with some items being added to represent “smartness” of the Alexa skill. These items used a 10-point Likert scale. As supplementary usability measures for general expectations and evaluations of Alexa’s responses, we elicited participants’ agreement level with the following 5 questions on a 10-point Likert scale: “The way Alexa talked to me irritated me,” “Alexa’s responses were appropriate,” “I felt like Alexa was putting me down,” “I wish Alexa’s responses had been briefer,” and “I wish Alexa’s responses had been longer.”

Emotions	Pre-interaction Mean (SD)	Post-interaction Mean (SD)	Pre vs. Post Difference
Active	6.78 (2.21)	6.70 (2.65)	F(1,38)=.07, p=.79
Calm	7.10 (2.31)	7.10 (2.35)	F(1,38)=.001, p=1.0
Content	6.40 (2.70)	6.67 (2.36)	F(1,38)=.71, p=.41
Enthusiastic	6.43 (2.17)	6.25 (2.50)	F(1,38)=.37, p=.55
Happy	6.67 (2.30)	6.77 (2.43)	F(1,38)=.11, p=.74
Angry	1.65 (1.41)	1.68 (1.49)	F(1,38)=.03, p=.87
Anxious	2.73 (1.99)	2.25 (1.95)	F(1,38)=4.51, p=.09
Embarrassed	1.75 (1.35)	1.70 (1.49)	F(1,38)=.04, p=.85
Nervous	2.68 (2.21)	2.10 (1.81)	F(1,38)=8.58, p < .01
Sad	2.73 (2.33)	2.30 (2.10)	F(1,38)=4.06, p=.05

Table 2. Pre- and post-interaction emotional states

## 4 RESULTS

Before the main analyses, we investigated whether self-disclosure behaviors differ across demographic variables in our dataset. While non-native speakers tended to use less words ( $t(37) = 2.32$ ,  $p = .03$ ,  $\eta_p^2 = .13$ ), and spend less time ( $t(37) = 1.20$ ,  $p = .053$ ,  $\eta_p^2 = .10$ ) on the interaction compared to native speakers, their use of positive and negative emotional words did not differ significantly ( $ps = .24$ ). Also, current smart-speaker users did not differ from non-users on any of the 4 self-disclosure behaviors ( $ps = .33$ ). More importantly, the significant main effects of backchanneling cues on active listening perceptions (see section 4.1. for specific findings) remained significant after controlling for language difference as well as previous usage ( $F(1, 36) = 5.06$ ,  $p = .03$ ,  $\eta_p^2 = .12$ ). In other words, **self-disclosure behaviors were mostly consistent across different demographic groups.**

### 4.1 Effects of backchanneling on active listening perceptions

We used an independent-samples t-test to assess whether the use of backchanneling cues enhances users’ perception of smart speakers as active listeners (H1). Participants in the backchanneling condition ( $M = 3.91$ ,  $SD = 1.96$ ) evaluated Alexa as being a better active listener compared to the control condition ( $M = 2.56$ ,  $SD = 1.68$ ) with ( $t(38) = 2.34$ ,  $p = .03$ ,  $\eta_p^2 = .13$ ). Therefore, **our data support H1.**

### 4.2 Emotional contrast before and after interaction with Alexa

We also examined if backchanneling cues had any effects on users’ (a) change in emotional state, (b) self-disclosure behaviors, and (c) perceived emotional support, as suggested in H2. We used a 2 (backchanneling vs. control)  $\times$  2 (pre- vs. post-emotions) mixed model repeated-measures analysis of variance (ANOVA) to examine the effects on (a) change in emotional state. The findings showed no significant differences between the backchanneling and control groups in emotional

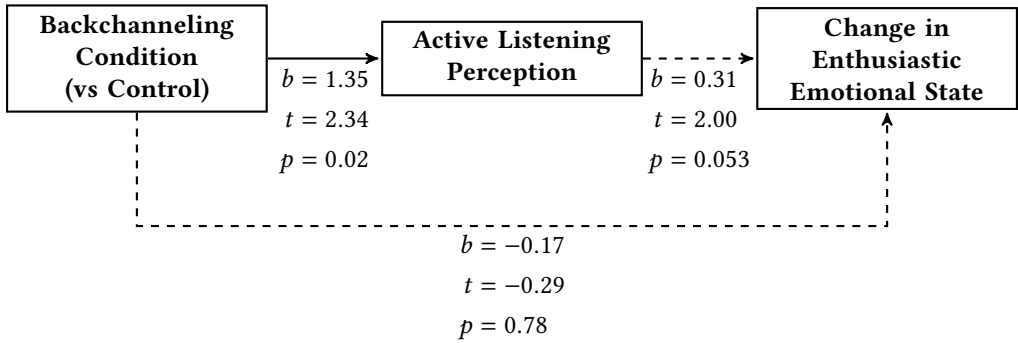


Fig. 2. Significant positive mediation effects of backchanneling on change in enthusiastic emotional state through increased active listening perception.

changes during the interaction, for any of the 10 emotions ( $ps > .12$ ). As such, our data did not support H2a. There was however a significant reduction in nervousness ( $F(1,38) = 8.58, p = .006, \eta_p^2 = .18$ ) after interacting with Alexa (see Table 2; due to the non-significant difference in emotional states between the backchanneling and control conditions, the emotional state of two groups are combined).

To further examine if backchanneling had an effect on (b) perceived emotional support and (c) self-disclosure behaviors, we conducted a series of independent-samples t-tests. We did not find evidence to suggest that backchanneling improved perceived social support obtained from Alexa (H2b;  $t(38) = 0.31, p = .76, \eta_p^2 = .003$ ). In terms of self-disclosure behaviors (H2c), backchanneling was not associated with more interaction with Alexa in both time spent ( $t(37) = 0.33, p = .75, \eta_p^2 = .003$ ) and words used ( $t(37) = 0.56, p = .58, \eta_p^2 = .01$ ), nor promoted more use of positive emotional words ( $t(37) = 1.15, p = .26, \eta_p^2 = .03$ ). However, backchanneling had a significant effect on the use of negative words ( $t(37) = 2.26, p = .03, \eta_p^2 = .12$ ) – participants used more negative words in the backchanneling condition ( $M = 0.70, SD = 0.47$ ), compared to the control ( $M = 0.40, SD = 0.35$ ). **Overall, our data, thus, did not support H2.**

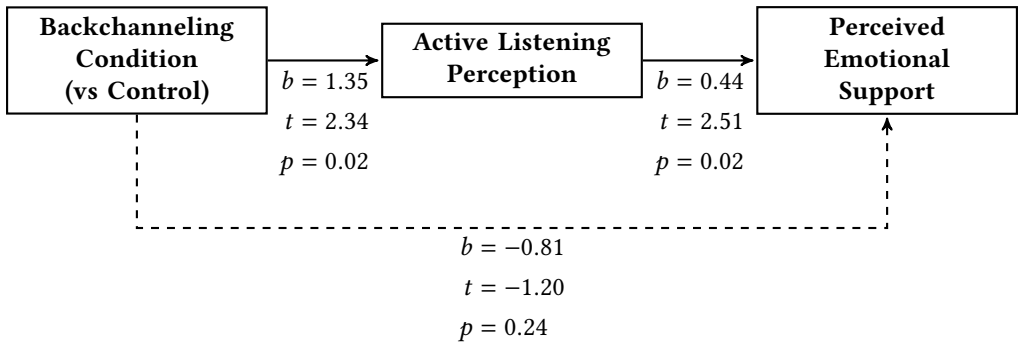


Fig. 3. Significant positive mediation effects of backchanneling on perceived emotional support from Alexa through increased active listening perception.

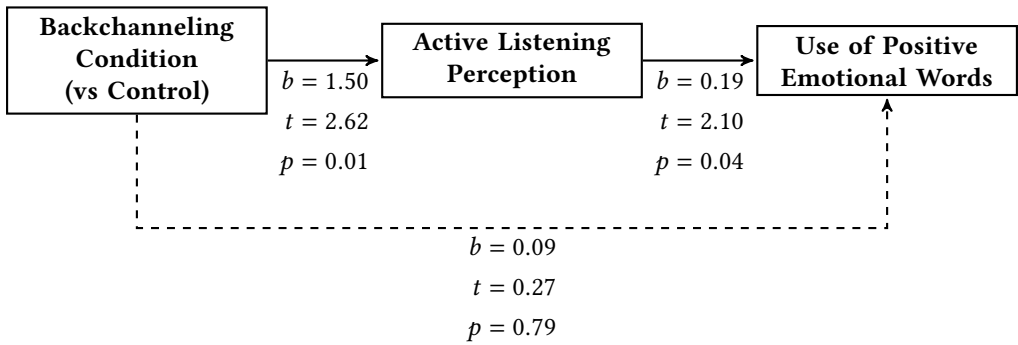


Fig. 4. Significant positive mediation effects of backchannelling on the use of positive emotional words through increased active listening perception.

### 4.3 Mediation effects toward emotional support and self-disclosure

As proposed in H3, it is possible that backchannelling can indirectly improve emotional feelings and expressions through elevated perception of active listening. To test this possibility, we ran mediation analyses using PROCESS macro (Model 4) [27] on (a) change in emotional state, (b) perceived emotional support and (c) self-disclosure behaviors. Taking into consideration the pre- and post-measurement structure of (a) emotional states, we first ran some preliminary repeated-measures analyses. Keeping in mind the significant effect of backchannelling on perceived active listening (IV to mediator), but no significant effects of backchannelling on any of the emotional changes (IV to DV), we first checked if emotional states changed based on changes in active listening perceptions (mediator to DV).

We found that pre to post changes were significantly affected by active listening perceptions only for enthusiasm ( $p = .047$ ), but not for the other 9 emotions ( $ps > .05$ ). When a mediation analysis was run for enthusiasm as the DV (calculated by deducting pre- from post-enthusiasm states), significant indirect effects emerged (indirect effect = .42, 95% bias-corrected 10,000 bootstrap CI [0.0046, 1.0053]; see Figure 2), suggesting that **backchannelling increased the feeling of enthusiasm due to heightened perception of active listening.**

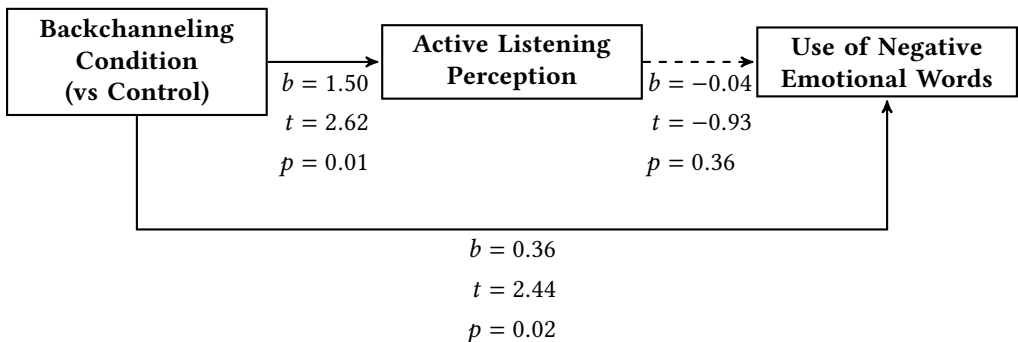


Fig. 5. Non-significant mediation effects of backchannelling on the use of negative emotional words through active listening perception.

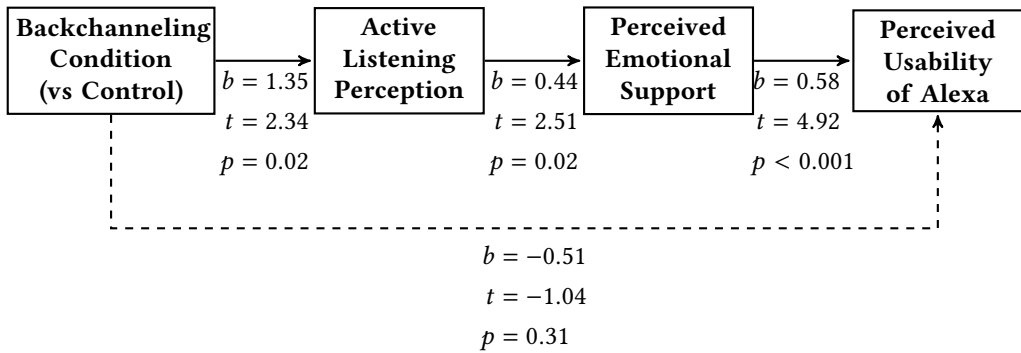


Fig. 6. Significant positive serial indirect effects of backchannelling on perceived usability through increased active listening perception and emotional support.

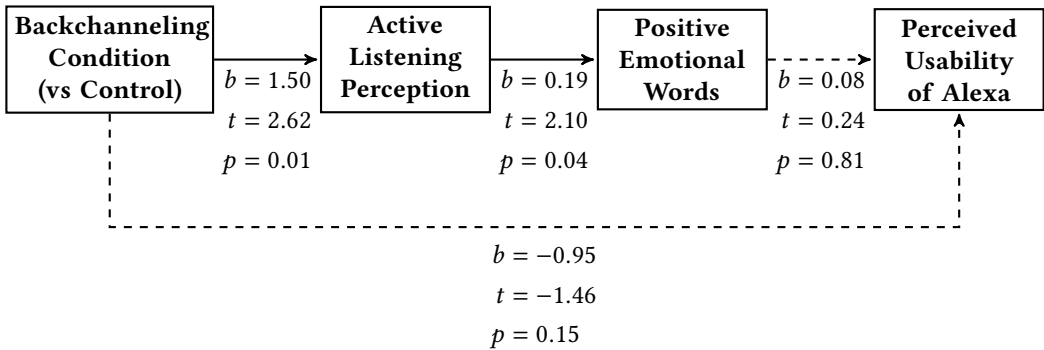


Fig. 7. Non-significant serial indirect effects of backchannelling on perceived usability through active listening perception and the use of positive emotional words.

For (b) perceived emotional support, the mediation analysis also suggested that **backchannelling (vs. control) led to increased emotional support from Alexa, by increasing user perceptions of active listening** (indirect effect = .60, 95% biased-corrected 10,000 bootstrap CI [0.0297, 1.4566]; see Figure 3). Similarly, for (c) self-disclosure behaviors, **active listening perception mediated the positive backchannelling effects on increased use of positive emotional words** (indirect effects = .29, 95% biased- corrected 10,000 bootstrap CI [0.0070, 0.8539]; see Figure 4). Together, these significant mediation effects indicate that, while the effects of backchannelling on emotional support and positive self-disclosure did not occur directly, the effects took place indirectly through (mediated by) active listening perceptions. That is, when participants considered smart speakers as active listeners due to backchannelling, they also perceived these devices as more emotionally supportive. Similarly, the perception of smart speakers as active listeners was associated with increased use of positive words during self-disclosure.

However, the significant main effect of backchannelling on the use of negative emotional words was not explained by enhanced active listening perception (indirect effects = -.05, 95% biased-corrected 10,000 bootstrap CI [-.2045, .0491]; see Figure 5). In addition, active listening perception did not serve as a statistically significant mediator for interaction duration (indirect effects = -.33,

95% biased-corrected 10,000 bootstrap CI [-63.21, 44.19]) nor word count (indirect effects = 3.75, 95% biased-corrected 10,000 bootstrap CI [-144.19, 107.29]).

#### 4.4 Serial mediation toward enhanced usability and other supplementary usability effects

Given the significant and positive mediation effects of backchanneling on perceived emotional support and the use of positive emotional words, we explored if those effects would result in improved usability of the smart speaker service (RQ1). A serial mediation analysis, based on PROCESS Model 6 [27], suggested that **increased perceived emotional support is positively related to attitudes toward Alexa** (indirect effect = .35, 95% biased-corrected 10,000 bootstrap CI [0.0149, 0.9645]; see Figure 6). However, the expression of more positive emotional words did not enhance perceived usability of Alexa (indirect effect = .02, 95% biased-corrected 10,000 bootstrap CI [-0.1693, 0.3737]; see Figure 7).

When we analyzed the supplementary usability measures, we found that participants felt interrupted by the use of pseudo-random backchanneling. Specifically, participants in the control group ( $M = 2.25$ ,  $SD = 1.71$ ) scored lower on irritation compared to the active listening group ( $M = 3.70$ ,  $SD = 2.45$ ) ( $t(38) = 2.17$ ,  $p = .04$ ). This finding suggests that allocating space for silence could also help to prevent interruptions and consequent irritation. Even though research on social robots has been progressing in this domain [45], smart speakers have not deployed these features. However, user perceptions of other aspects of Alexa's responses (e.g., interaction length, appropriateness) were not significantly influenced by backchanneling ( $ps > .48$ ).

In summary, interacting with Alexa decreased some negative emotions such as sadness, nervousness, and anxiety in both control and active listening conditions. More importantly, adding verbal backchanneling caused participants to perceive Alexa as a much more active listener, which in turn, positively affected their perceived emotional support and expression of positive emotions. In particular, when users felt like they received emotional support through an actively listening Alexa, it led to an improved user experience.

#### 4.5 Qualitative findings

We also conducted interviews at the end of the study. Given the exploratory nature of the study, we decided to use semi-structured interviews. During the interview session, we focused on understanding participants' experiences with Alexa, their expectations regarding our skill, and usefulness of the skill in the context of therapy and counseling (see the supplementary document for the semi-structured interview guide). Furthermore, we asked their ideas about how smart speakers can potentially be used to support mental health and wellbeing. These interviews were audio-recorded. Following each interview, one author compiled transcripts of a participant's responses.

To analyze interview data, one author performed a bottom-up thematic analysis to identify common themes in the dataset using a qualitative interpretivist approach described by Braun and Clarke [11]. A second author checked the generated themes against data to ensure consistency and avoid any potential biases. In case of disagreement, researchers engaged in a follow-up discussion to reach consensus. In the following section, we describe the resulting final themes, which converged into 3 major ones. The first theme was related to the efficacy of using smart speakers for self-disclosure ( $N = 5$ ). The second theme discussed the potential of utilizing backchanneling cues as effective verbal continuers, including the positive evaluation of the pseudo-random backchanneling cues ( $N = 3$ ), and the need for backchanneling for those in the control condition ( $N = 5$ ). Negative user inputs emerged as a third theme. For some users, the pseudo-random timing was disruptive ( $N = 2$ ). Others expressed needs for a more tailored and empathetic response from the smart speaker ( $N = 5$ ). Future directions and potential use suggested by users are also added as part of our qualitative

findings (N = 4). We have labeled participants in the active listening condition as P1–P20 and those in the control condition as P21–P40.

**4.5.1 Smart speakers can effectively support self-disclosure.** A key barrier to self-disclosure is the fear of negative evaluation and judgement. A number of participants noted that a smart speaker can help address this barrier given that it is a device that does not have the capacity to judge them. For example, P16 commented that “*Alexa is not a person, it’s anonymous, it’s like you can talk to it more. You feel more comfortable.*” Similarly, P10 noted that “*the good thing is that there is no human around so that you can reveal whatever there is about your personal stuff.*” This perceived ease of disclosure to smart speaker is consistent with prior studies involving virtual agents [49].

Participants also commented about the positive outcomes of disclosure to smart speakers. P15 commented about her interaction with smart speakers during the study: “*what I liked [that it] made me think about different things, which is interesting that [a device] can make you think of something that you wouldn’t think of otherwise.*” P14 thought her interaction with our system was similar to talking to her real-life therapist: “*She [Alexa] is so close to my first therapist [...] it was good to talk. The less the therapist talks the more like a mirror. You see your own reactions.*”

**4.5.2 Pseudo-random backchanneling as effective verbal continuers.** Participants in the control condition — without any backchanneling — repeatedly pointed out the need for having verbal continuers. P32 from the control condition suggested to “*add some cues between when I’m speaking [...] Like if I say something emotional you would say ‘uhum’ or something like that. Or that ‘I understand’. Some dynamic responses [are necessary], instead of just listening.*” P30 also commented about the lack of perceived active listening: “*there could be things like ‘yeah?’, ‘aha’, ‘I am listening’ to show that she is listening.*” These findings clearly show the need for backchanneling to support self-disclosure.

For most participants in the active listening condition, the pseudo-random backchanneling was effective as verbal continuers. P3 commented that “*it responded to what I was saying — ‘aha’ like it was a real person.*” As intended, these backchanneling cues helped to promote the perception that smart speakers are active listeners: “*[backchanneling] gives you the cue that Alexa was listening to me. Like uhum, yes, ...*” (P10). Another participant noted the lack of backchanneling in current devices and preferred our system: “*Yeah it is really interesting that you feel it is listening to you. [With Siri] you have to say your statement completely and then you pause for the reaction. And then you speak whatever you wanna say. But with this one, it is more continuous. You don’t need to stop and start and stop. I think it’s really good you have something [like this]*” (P20).

However, pseudo-random backchanneling can also inadvertently interrupt users. P07 noted that “*[The other backchanneling cues] fit to what I was saying but this one ‘hm’ stood to me as weird. It was kinda like [...] out of time.*” The backchanneling cues out of order can also be problematic: “*[Alexa] kinda interjected by saying ‘okay’ and it was kinda jarring because I thought I had done something to trigger her.*” (P18). To address these issues, future work should develop other heuristics beyond just pre-determined time interval for backchanneling cues. For example, long duration of silence or pause from the user can potentially indicate an opportunity to deliver backchanneling cues and verbal continuers. For this, it will be important to identify optimal pause intervals in user speech for backchanneling cues.

**4.5.3 Need for more elaborate and empathetic responses.** Participants also expressed a need for more elaborate and empathetic responses from smart speakers beyond simple backchanneling cues used in the study. P10 suggested longer responses: “*I wish that [the responses] even longer than that [...] longer statements could motivate me to talk more and to share.*” Participants also wanted smart speakers to adapt to the content and characteristics of their self-disclosure. P07 expected

interactions to reflect prior disclosure: “if it had asked about specific points that I had said [...] then it would have definitely felt like it was more involved.”

Similarly, participants also thought more empathetic responses from smart speakers will be useful in this context. P18 suggested “saying phrases like, ‘oh I understand’, ‘oh that must be tough’ ..., [being] more empathetic.” P33 from the control condition commented that “when I say, ‘this has impacted me emotionally’ [...] I expected [responses] like ‘I feel you’”

However, delivering such personalized and context-specific responses will require understanding the content and emotion disclosed by the user. This can be challenging to achieve, particularly in a privacy preserving manner.

**4.5.4 Suggested future directions from participants.** A number of participants were very positive about the use of smart speakers to deliver mental health interventions. P37 commented that “even though I have a therapist and a psychiatrist I can’t see them every day. Of course, I only go once every two weeks or something. You could just have Alexa at home to talk to her whenever”. P14 pointed out that immigrants can have significant difficulties in reaching out to a therapist in a different country due to language barrier and suggested that smart speakers can be used to address this: “I was thinking one of the biggest problems in therapy is that if you are living in another country you can’t always find the therapist you can talk to. Let’s say you see your therapist [and they] decide what therapy you need, like maybe you need more cognitive or behaviorist, and they’re going to prescribe it and then Alexa will take it from there. She can practice it with you in whatever language you want. [...] I’ve been thinking about it for a couple of years actually. Do we really need to be in the same room as a therapist?”

Participants also suggested that social isolation and loneliness can potentially be addressed by smart speakers. P10 commented that: “It could be very useful especially for those who spend most of their time alone and need companions. Even for those who say they don’t need a companion; I argue that it will be still interesting for them to try such an agent. Because it is not just about talking to another human being. Even imagining that something is listening to you would actively engage your mind and [help to] reflect on your own.” P15 also suggested that our system based on smart speakers can benefit the older population to address their social isolation [56].

Overall, there was a persistent theme regarding the need for an active listener during the course of one’s daily activities. As P18 commented: “sometimes we can’t get her [their daughter] to sleep and you just wanna like... scream into a pillow or something right? [...] to get it off your chest [...] Being able to express that and have some level of interaction back is useful. [...] Whether it’s for companionship, or meditative, or therapeutic, to feel like someone is listening”.

## 5 DISCUSSION

In this study, we implemented and empirically evaluated the use of smart speakers as active listeners for supporting disclosure. More specifically, we developed Alexa skills with pseudo-random backchanneling to indicate active listening behaviors. Our findings show that backchanneling can improve the degree of perceived active listening by smart speakers. Furthermore, perceived active listening by smart speakers can foster self-disclosure, provide emotional support, and improve usability. In this section, we will discuss the implications of these findings as well as identify research opportunities for the CSCW and the broader HCI community.

### 5.1 Implications for design and usability of smart speakers

Our findings offer important design implications which can help to advance recent research trends in the HCI community regarding smart speaker interaction design [13, 14]. Specifically, these findings can extend interaction models currently supported by smart speakers. Users’ engagement with smart

speakers are now mostly limited to task-specific commands with the resultant dialogues remaining short and often not spanning more than a single turn. A smart speaker with active listening can enable different types of interactions with users wherein dialogues are more open-ended, longer in duration, and span multiple turns, which can be particularly useful in sustaining user engagement. For instance, multi-turn dialogues can improve “message interactivity” – the degree of interconnected and threaded conversations, which led to better engagement and positive persuasive outcomes [7]. In addition, active listening can promote a smoother and more efficient acclimation process in broadening the use of smart speakers among certain age groups. For instance, older adults with less technological experience are hesitant to use smart speakers because of reliability concerns (e.g., reluctance to rely on Alexa for important reminders) [64], as opposed to children, who are more prone to personify and emotionally associate with smart speakers [24, 73]. Thus, future work should explore other interactive and conversational features beyond basic continuers that can help to transform smart speakers from mere task agents to companions with perceived empathy across different age groups (e.g., [65]).

Perception of active listening in smart speakers can also help to improve usability. Not only did our study empirically demonstrate that active listening perception served as a precursor to enhanced usability, participants in the control study condition also repeatedly reported that the lack of backchanneling cues to be a serious usability issue. In particular, the positive effects of active listening on usability were led by increased emotional support and the use of positive (but not negative) emotional words. This shows how even simple interface signals of active listening, such as backchanneling cues employed in this study, can generate positive thoughts as well as improve usability. This seems to be a significant cue effect considering the primarily transactional nature of conversations between users and conversational agents, and the reluctance many users express in terms of building a social relationship with these agents [14]. These findings are consistent with Clark et al. [14], which also noted the importance of “the role of the agent as a listener”.

That said, our findings indicate that the design of smart speakers with active listening must be consistent with user expectations, limit interruptions, and enable a supportive environment for continuing dialogue. Luger and Sellen [50] pointed out that especially for users with less technical knowledge, the large gap between expectations and experience led users to become less tolerant of system failures and limited their use of smart speaker use. In our study, some participants noted that mistimed and unexpected backchanneling can interrupt user focus and interaction. Future studies should work on developing heuristics for backchanneling that can be used to avoid such user interruptions. For example, a long pause from a user can potentially indicate an opportunity to deliver backchanneling cues encouraging them to continue their interaction. This will require identifying appropriate pause intervals in user speech to deliver backchanneling cues. In addition, changes in tone and other non-content qualities of user interaction with the smart speaker could be explored as potential triggers for introducing backchanneling cues into the conversation. Furthermore, design efforts can be geared toward conveying backchanneling via non-auditory means (e.g., using light behaviors [43, 44]) which can be not only be more subtle and less intrusive, but also more accessible, especially for hearing-impaired users [8, 9].

Our study participants also noted the need for context- and sentiment-specific backchanneling cues and verbal continuers (e.g., a smart speaker replying “I am sorry to hear that” after a user discloses a negative experience). There exist many psychological, physical, and social contextual factors that deter users from actively engaging with smart speakers, which calls for context-sensitive conversation management features [13]. Studies with chatbots have shown that such expressions of sympathy, even coming from a machine, is perceived as more supportive by users facing a health issue than straightforward provision of information and advice [48]. However, this can be challenging since it will involve real-time understanding of contexts and appropriate classification



of sentiments conveyed by the users. Given the limited computational capabilities of smart speakers, this might require offloading data processing to servers, which will create considerable time lag as well as raise serious privacy concerns. To address these issues, future work should focus on more optimized data processing in the devices to identify contexts and sentiment. This will involve both speech recognition (e.g., detecting keywords indicating sentiment and contexts) as well as audio analysis (e.g., pitch indicating positive sentiment).

## 5.2 Applications to therapy and mental health support

Given the therapeutic benefit of disclosure, our findings also have important implications for mental health interventions. Smart speakers with active listening can help to engage users in regular self-disclosure practices, and such disclosure can lead to positive wellbeing outcomes as prior studies show [4, 12, 17, 22, 40, 59]. From our qualitative interviews, we found that some of our participants were particularly positive about the potential use of smart speakers to remotely deliver therapeutic interventions. They suggested the use of smart speakers to provide just-in-time interventions and supplement their (traditionally infrequent) interactions with mental health experts.

In addition, smart speaker technology can help to address emotional fatigue and burnout faced by therapists. Vicarious and secondary trauma can lead to emotional fatigue and burnout among therapists and mental health practitioners [55]. Their job often requires exposing themselves to clients' most difficult emotions, which can significantly impact their own emotional and mental wellbeing [55, 66]. As our qualitative findings indicate, users are willing to use smart speakers to share intimate feelings, especially when in-person therapy is unavailable at the moment. This suggests that therapists can potentially use smart speakers as assistive tools to continue facilitating effective disclosure from patients. By integrating smart speakers in their workflow, therapists thus can potentially reduce their continuous exposure to traumatic disclosure.

However, there are still considerable challenges that need to be addressed before smart speakers can be used to successfully deliver mental health interventions. Interactions supported by smart speakers are considerably different from current eHealth practices using webpages and mobile apps. As such, existing messages and interactions will need to be adapted for smart speakers. For instance, participants in our study called for more adaptive and empathetic responses based on users' specific input. Furthermore, sustaining engagement is often critical for successful mental health interventions. However, not much is known about how to design smart speaker interactions to keep users engaged over a period of time. It will be critical to design and compare different interaction patterns in smart speakers to identify their strengths and trade-offs relevant to sustaining engagement.

## 5.3 Trust, privacy and ethical concerns

While smart speakers are becoming increasingly popular, there is a lack of transparency regarding how these devices collect, handle, and process user data. Given that disclosure can contain intimate and personal information, it is essential to understand the risks of self-disclosure to commercialized smart speakers. As such, users' trust and privacy concerns must be addressed before smart speakers can be used to support disclosure and enable therapeutic interventions. Our approach aimed to address such privacy issues by using "context free" interactions — not using or recording any user content to deliver backchanneling cues. Recently, Amazon introduced Health Insurance Portability and Accountability Act (HIPAA) compliant Alexa skills [20]. Similar steps can be used to ensure users' privacy regarding their disclosed information to an active smart speaker. In this regard, this study offers implications regarding protecting users' and patients' safety when utilizing conversational user interfaces (CUIs) for therapeutic self-disclosure via active listening

(mostly studied in the chatbot context), which has been an ongoing challenge in fostering human-to-CUI collaboration within the CSCW community [61]. Beyond supporting dyadic interactions between CUIs and users, this study also suggests expanded collaboration between those dyads and professional or informal health care providers (e.g., therapists, caretakers), by sharing the responsibilities and supporting collaborative tasks.

A system focusing on therapeutic support must address ethical and user safety concerns as well [26]. For instance, users may feel deceived after finding out the limitations of smart speaker capabilities to provide support. Weizenbaum, the creator of one of the earliest chatbots (Eliza), noted the danger in “how easy it is to create and maintain the illusion of understanding” (p. 42) [80]. Similar to Eliza, our skill concealed its lack of understanding, which can create technical issues beyond ethical concerns. As Weizenbaum stated, while “it has a crucial psychological utility in that it serves the speaker to maintain his sense of being heard and understood” (p. 42), “to encourage its conversational partner to offer inputs from which it can select remedial information, it must reveal its misunderstanding” (p. 43) [80]. Misunderstanding itself can evoke user safety concerns as well. For instance, without being able to detect users’ disclosure to engage in harmful activities, the system cannot offer urgent preventive support. Thus, going forward, it will be essential to identify use cases where active listening would not be appropriate, and merit deeper therapeutic interventions that are personalized and adapted to users’ needs. Admittedly, there exist challenges to developing a context-aware and personalized system, while still preserving privacy. Future work can explore ways to detect users’ emotional status (e.g., via specific keywords and user prompts) without compromising data security and offer richer active listening cues beyond backchanneling. In fact, Ward [77] found that vocal attributes such as low pitch can be sufficient to determine when the backchanneling should be offered while building a responsive dialog system. This will be a fruitful venue to explore considering the significant emotional effects we found from a single-session of backchanneling cues that were delivered devoid of any context awareness. In addition, a system aiming to support self-disclosure must explicitly convey its abilities and limitations. It should also ensure access to external resources (e.g., hotline numbers) similar to many apps (e.g., PTSD Coach [41]) and conversational agents (e.g., Woebot [21]) focusing on mental health that face similar concerns of perceived ability in helping users in distress [26].

#### 5.4 Study limitations and future directions

In our study, we aimed to evaluate the effectiveness of pseudo-random backchanneling to support effective self-disclosure. To do so, we used pre- and post-questionnaires to measure subjects’ emotional states before and after their single-session interactions with Alexa. While this approach is consistent with prior work on examining the psychological and emotional effects of self-disclosure (e.g., [28]), we acknowledge that extended disclosure sessions over several weeks may be needed in order to observe sustained emotional changes. The single-session study design may have also led to only finding few significant effects, with seemingly small effects. For instance, despite the statistically significant difference between conditions, active listening perception was very low across conditions (3.23 out of 10-point scale), with only 1.57 point difference between conditions. In addition, while the use of negative words was directly enhanced by backchanneling cues (increased to 0.7 from 0.4 of words), the negative words per interaction only amounts up to about 4.7 words (vs. 2.7 words). However, the fact that we found any significant effects from a single-session study is highly encouraging. Prolonged and sustained interactions with smart speakers that can reach a wide user base can lead to more pronounced effects, which can be examined by future studies. Moreover, considering the massive diffusion of smart speakers and the millions of exchanges that users all over the world have with them on a daily basis, the modest effect noticed in our study can

translate to hundreds of thousands of users perceiving greater emotional support and engaging in beneficial self-disclosure with their smart speakers.

There are of course ethical concerns with the use of pseudo (non-receptive) smart speaker responses, as it constitutes a form of deception to users. Yet, we would like to note that the participants in our study had a reasonable understanding of the abilities of these devices in that they not only correctly identified that they were interacting with a device but also noted the ease of disclosure to a non-human entity, which is consistent with prior work [49]. Another related concern regarding the pseudo-random nature of the smart speakers' empathetic response is that no claim can be made to support its efficacy for therapeutic interventions, since a) the interactions did not specifically focus on talking about negative or traumatic life events, and b) the responses were not specifically catered to individuals' therapeutic needs. Still, self-disclosure is an established intervention process for both clinical and non-clinical populations and events (e.g., [22]), and the importance of active listening for clinical populations has been well-established [18, 30]. Thus, there is room for future research to focus on specific clinical or therapeutic contexts and interactions in order to examine the potential of smart speakers for interventions in a more focused manner. While there may be other platforms that can facilitate a more tailored and time-sensitive backchanneling to better promote self-disclosure, studying backchanneling effects in the context of smart speakers is meaningful in that our findings can be applicable to many other consumer devices supporting voice interactions. Specifically, there are "hundreds of millions of Alexa-enabled devices" [3] and Google Assistant is now available on more than one billion devices [29]. Our findings regarding backchanneling and self-disclosure are potentially relevant for this wide range of consumer devices. As such, future studies should continue examining the therapeutic use of consumer products such as smart speakers which can offer broader application reach, compared to custom-developed systems.

## 6 CONCLUSION

This study shows how self-disclosure through smart speakers can have significant positive effects on health and wellbeing by empirically evaluating the use of smart speakers as active listeners. Specifically, we leveraged the Amazon Alexa framework to deliver pseudo-random backchanneling cues during user interactions to indicate active listening. Our findings show that backchanneling significantly improved the perceived level of active listening in smart speakers. It also resulted in more emotional disclosure with increased use of positive words from participants. Furthermore, perception of smart speakers as active listeners was positively associated with perceived emotional support, which in turn was significantly associated with participants' positive attitudes toward smart speakers.

These findings can help us design more engaging and more usable smart speakers. For instance, we learned that the inclusion of simple interactive cues in the form of backchanneling can allow users to consider smart speakers as confidants to share emotions and also obtain emotional support. Such findings not only point us to the specific design elements we should incorporate in technology-based health interventions but also suggest opportunity areas (e.g., adaptive or personalized backchanneling; more complex interpersonal conversational cues to increase active listening perceptions). Our study also shows the feasibility of using smart speakers to provide therapeutic support. Given their wide adoption, smart speakers can play a crucial role in addressing mental health and wellbeing issues at scale. More generally, it appears that verbal backchanneling by smart speakers serves as a subtle, but powerful, social lubricant that can improve user experience regardless of interaction context.

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