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Assessment of adoption, usability, and trustability of conversational agents in the diagnosis, treatment, and therapy of individuals with mental illness

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BOSTON UNIVERSITY
SCHOOL OF MEDICINE

Thesis

**ASSESSMENT OF ADOPTION, USABILITY, AND TRUSTABILITY OF
CONVERSATIONAL AGENTS IN THE DIAGNOSIS, TREATMENT, AND
THERAPY OF INDIVIDUALS WITH MENTAL ILLNESS**

by

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B.S., Purdue University, 2017

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Master of Science

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ABSTRACT

Introduction

Conversational agents are of great interest in the field of mental health, often in the news these days as a solution to the problem of a limited number of clinicians per patient. Until very recently, little research was actually done in patients with mental health conditions, but rather, only in healthy controls. Little is actually known if those with mental health conditions would want to use conversational agents, and how comfortable they might feel hearing results they would normally hear from a clinician, instead from a chatbot.

Objectives

We asked patients with mental health conditions to ask a chatbot to read a results document to them and tell us how they found the experience. To our knowledge, this is one of the earliest studies to consider actual patient perspectives on conversational agents for mental health, and would inform whether this avenue of research is worth pursuing in the future. Our specific aims are to first and foremost determine the usability of such conversational agent tools, second, to determine their likely adoption among individuals

with mental health disorders, and third, to determine whether those using them would grow a sense of artificial trust with the agent.

Methods

We designed and implemented a conversational agent specific to mental health tracking along with a supporting scale able to measure its efficacy in the selected domains of Adoption, Usability, and Trust. These specific domains were selected based on the phases of interaction during a conversation that patients would have with a conversational agent and adapted for simplicity in measurement. Patients were briefly introduced to the technology, our particular conversational agent, and a demo, before using it themselves and taking the survey with the supporting scale thereafter.

Results

With a mean score of 3.27 and standard deviation of 0.99 in the Adoption domain, we see that subjects typically felt less than content with adoption but believe that the conversational agent could become commonplace without complicated technical hurdles. With a mean score of 3.4 and standard deviation of 0.93 in the Usability domain, we see that subjects tended to feel more content with the usability of the conversational agent. With a mean score of 2.65 and standard deviation of 0.95 in the Trust domain, we see that subjects felt least content with trusting the conversational agent.

Conclusions

In summary, though conversational agents are now readily accessible and relatively easy to use, we see there is a bridge to be crossed before patients are willing to

trust a conversational agent over speaking directly with a clinician in mental health settings. With increased attention, clinic adoption, and patient experience, however, we feel that conversational agents could be readily adopted for simple or routine tasks and requesting information that would otherwise require time, cost, and effort to acquire. The field is still young, however, and with advances in digital technologies and artificial intelligence, capturing the essence of natural language conversation could transform this currently simple tool with limited use-cases into a powerful one for the digital clinician.

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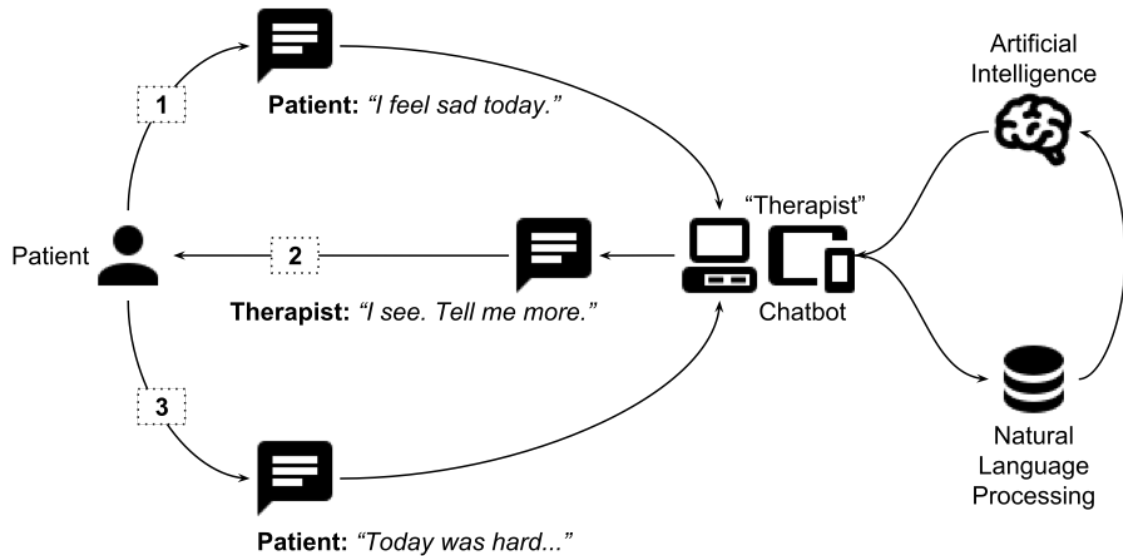
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INTRODUCTION

As technology advances and becomes more prevalent, it continues to prove valuable in suggesting new answers to long-standing problems in medicine. However, global access to a high quality, timely, standard of care for mental health services remains a major concern and challenge in every county in the world. The World Health Organization reports that serious mental illness (defined as depression, bipolar disorder, and schizophrenia) is the fourth leading cause of disability-adjusted life years ^[1] with a global estimated economic burden of 2.5 trillion U.S. dollars ^[2], and the World Health Organization further reports that on the global scale, there are just 9 mental health clinicians per 100,000 persons ^[3].

Major advances in artificial intelligence and natural language processing technologies in the last decade have seen both the emergence and rising popularity of a new class of digital tools capable of filling this gap - the conversational agent or virtual assistant. Conversational agents are tools existing as either physical hardware or digital software, such as Amazon's Alexa, Google's Assistant, or Apple's Siri, capable of understanding conversational input from a human, processing it through a task-oriented framework, and then responding with natural speech. As of 2018, 95% of individuals in the United States have access to a device capable of running such a conversational agent or virtual assistant ^[4], and the future of managing one's mental health appears to be moving towards AI and speech processing technology, according to the NHS Topol Review ^[5]. *Torous et al.* further determined from a clinical perspective that not only do patients with mental health diagnoses own smartphones, but that they are seeking app-based interventions and therapies to manage their symptoms ^[6].

Figure 1: Interaction pattern of a patient with a sample conversational agent.



Reproduced from Vaidyam et al. [7]; the conversational agent modeled here in the diagram is designed to act as a Rogerian psychotherapist.

As these devices and tools have become ubiquitous over the last decade, clinicians and researchers have begun to investigate the applications of conversational agents in mediating diagnoses or delivering therapies. They hold great promise therapeutically, as smartphones collecting passive data in the background know much more about a patient than their therapist and are capable of notifying both patient and clinician of adverse or risk events in real-time. Though we inch closer to this concept of a near-human virtual therapist being delivered by an app on a smartphone that may have once seemed like science fiction, little research has been conducted on whether patients are willing to use - or trust - such a therapist with no true experience, emotion, or face.

Current Limitations of Technology

Vaidyam et al. determined through literature analysis ^[7] noted several key areas in which conversational agent technology could be vastly improved before consumer or patient interaction reaches a threshold of acceptability.

As current natural language processing methods and techniques are not capable of understanding the tone of voice or context of speech, patients typically have found that open-ended questions, such as those used in behavioral therapy techniques, are not easily answered and instead lead to irrelevant conversation. Further, simple filler language used by all on a daily basis, such as “um” or “ah” appears to impact whether a patient believes a conversational agent to be human-like or not. Though in reality many strive to eliminate such filler language from conversation and their lexicon entirely, it appears to remain a uniquely human element of conversation. Finally, as noted in comments, the voice synthesized by the conversational agent still sounds robotic, and all the above factors coupled together negatively impact the conversational agent’s perception to a user or patient.

Further, conversational agents when scripted to respond to critical and emotional content could come across as disingenuous to a patient with illness such as post-traumatic stress disorder. Sharing sensitive or traumatic experiences with a conversational agent is apparently a very subjective matter as patients in some studies report the anonymity afforded by talking to a non-human entity allows them to express themselves more, but patients in a different study opened up about emotional experiences more when told the conversational agent they had been speaking to was actually a human reading a script. Perhaps a yet unknown or yet unquantified factor underlying empathetic connection

exists that could ascertain itself essential in fostering trust and allowing patients to open up about experiences they have had, a process key in traditional therapy.

There does appear, however, to be an “uncanny valley” effect surrounding conversational agents and eliciting empathy. The term “uncanny valley” is used to refer to the eerie feeling experienced when observing CGI-rendered hyper-realistic human models that could best be translated as “it looks too real to be real.” In the domain of conversational agents, however, *Vaidyam et al.* allude to the possibility of such an effect regarding empathetic response ^[7]; too little empathy could come across as robotic and may cause patients to avoid the conversational agent, but it also appears that too *much* could come across as disingenuous and cause patients to avoid them all the same. Patients that understand that a conversational agent is not a human with lived experiences would lose rapport with the agent if it responded to them “I too have struggled with depression,” as they would clearly know that struggling with depression is a uniquely human lived experience. Some patients could also develop an unhealthy attachment to a conversational agent as an emotional creature that may impede their ability to form social relationships.

There are many factors too that remain unknown due to the lack of data and reporting methods on how alliance is formed between patients and conversational agents. As conversational agents are still unable to understand or analyze complex medical diagnoses or inquiries they are still unable to truly understand the needs of a patient, regardless of condition. In response to questions regarding suicide, some have actually inappropriately replied "Maybe the weather is affecting you." The first step then to understanding patient usage or making sense of these factors is adoption and usability of the technology of conversational agents.

SPECIFIC AIMS

Conversational agents are of great interest in the field of mental health, often featured in the news as a solution to the problem of limited mental health clinicians available per patient. Until recently, little research was actually done in patients with mental health conditions, but these studies only included healthy controls. Little is actually known if those with mental health conditions would want to use conversational agents, and how comfortable they might feel hearing results they would normally hear from a clinician opposed to a conversational agent. Patients with mental health conditions were invited to ask a conversational agent about information relevant to their mental health and to provide feedback the experience. To date, this is one of the few studies to consider actual patient perspectives on conversational agents for mental health, and would inform whether this avenue of research is worth pursuing in the future. The specific aims of this project are to first and foremost determine the usability of such conversational agent tools, second, to determine their likely adoption among individuals with mental health disorders, and third, to determine whether those using them may develop a sense of artificial trust with the agent.

METHODS

A step-wise approach was used in carrying out the study. The first step was designing the interactions the conversational agent would possess with subjects or patients. The second step was implementation in software or hardware accessible to the target subject audience. The third step was developing a survey instrument to measure domains of interest among the subjects. The final step was approaching subjects for enrollment and conducting the study and recording results via a survey instrument. The study was reviewed and approved by the BIDMC IRB.

Conversational Agent Design

Interactions between the patient or subject and the conversational agent were designed to be as natural as those with a clinician. Interactions would begin with an open-ended question such as “How am I doing today?” but would eventually lead to complex questions such as “How does that [my step count] affect my mood?” The responses given by the conversational agent in this study are derived from pre-computed results that, during the course of the experiment, would not change depending on subject. After several iterations, the final set of interactions was decided upon and reproduced in *Table 1* and specifically implemented with configuration in *Appendix: Amazon Lex Configuration*.

Table 1: Interactions Supported by the Conversational Agent

Interaction	Sample Response
“How am I doing today?”	“You’re doing great! You’ve walked 4 miles and exercised for 85 minutes. Your mood seems better than usual, but you might be more anxious today.”
“What aspects of my mental health need improvement?”	“It looks like you might be more anxious today than normal. Everything else looks good.”
“What can I do to feel better right now?”	“Perhaps we could start a quick breathing exercise to lower your anxiety levels?”
“Why would <activity suggestion> make me feel better?”	“A quick breathing exercise can help lower your higher than usual anxiety levels. Many others say it’s worked for them, and it looks like it’s lowered your anxiety levels before.”
“I would like to speak with my doctor.”	“Sure. Calling your doctor for you...”

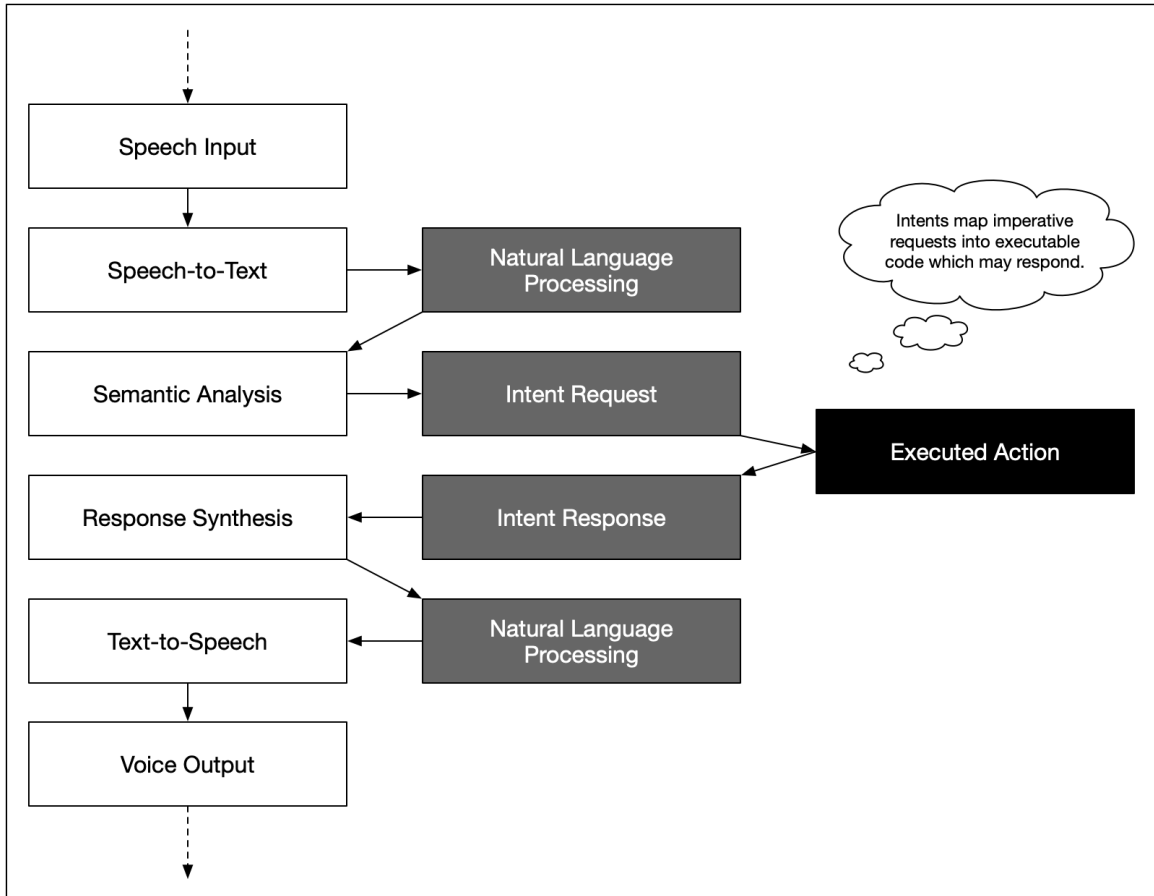
Several sample interactions supported by the conversational agent. Others were supported but mapped as aliases to the primary interactions listed for the sake of brevity and patient user experience.

To avoid excessive development overhead and high patient device requirements (such as operating system, network bandwidth, or device specifications), the conversational agent was not animated with a 3D avatar (referred to as an “embodied conversational agent”). Though technically feasible, this did not provide patients with a text-only version of the conversational agent as the intricacies of conversing with a human could only accurately be conveyed through a voice modality.

Conversational Agent Implementation

The conversational agent was implemented using the Amazon Lex platform. *Figure 2* shows the typical processing pipeline for a conversational agent to handle the processing of input speech into an executed action, and subsequently to an output voice. Amazon Lex was used to build the agent, abstracting all aspects of technical development except for the action to be executed, which is then provided with phrases that trigger the interaction (called an “Intent” in the program).

Figure 2: Typical Processing Pipeline of a Conversational Agent



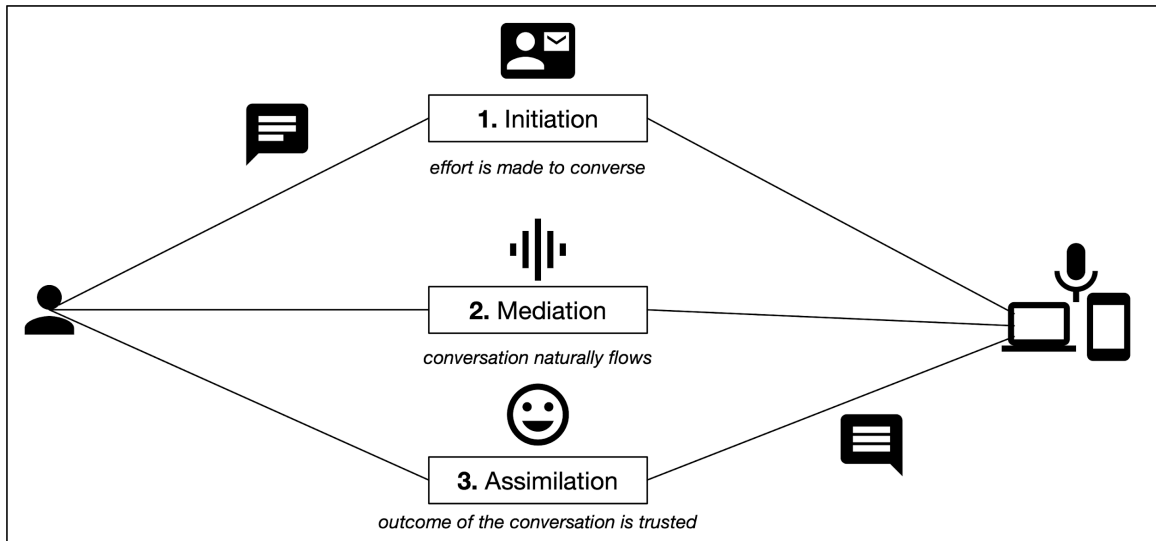
The processing pipeline involves components such as speech-to-text, natural language processing, sentence tokenization, sentence localization and grammatical adjustment, and text-to-speech, each typically provided by different programming frameworks and manually configured to operate in the manner described by the arrows.

The actions and their corresponding intents were provided as detailed in *Table 1* above. Once completed, such an agent may be interacted with offline on a microcomputing system, a typical desktop or laptop computer such as an Apple MacBook, or through a phone call forwarding system. The latter was observed to have the least risk of connection drop-out and the greatest likelihood of adoption amongst the population included in the study. Upon placing a phone call to a predefined number, the programmed conversational agent is triggered, looping until the phone call is hung up. Additionally, the same agent was installed on an electronic device contained by a nondescript cardboard box as a device the subject could potentially take home with them at some point in the future. This was done to both assure the subject that no third party could access their data and to demonstrate the potential chance of such a device being presented to them by a clinician in the future.

Measurement Scale

To measure and quantify responses to the conversational agent, a custom scale, shown in *Table 2*, was adapted and developed through the synthesis of two pre-existing scales, with minor contextual modifications to each question allowing the scale to better suit conversational agents. The first ten questions were adapted from the System Usability Scale (SUS), and the final five questions were adapted from the Digital Working Alliance Inventory (D-WAI).

Figure 3: Interaction Phases During the Usage of a Conversational Agent



The main interaction phases of a conversation as recognized by the conversational agent are best described in order as (1) initiation, (2) mediation, and (3) assimilation.

Each question was classified into one of three domains, as shown in *Figure 3*: Adoption signaled by initiation, usability signaled by mediation, and trust signaled by assimilation. Through classifying the different phases of interaction during a conversation with a conversational agent, these three domains were determined to be the most important to measure when observing differences between clinical interactions without conversational agents and those with. The act of initiating conversation with the conversational agent is influenced by a patient's adoption of the technology; the act of mediation during the conversation by accepting the conversational agent's response as well as replying to it as the next natural step is influenced by the patient's usability of the technology; the act of assimilation of the conversational agent in the mind as yet another humanoid entity is influenced by the patient's trust of the technology.

Table 2: The Conversational Agent Usability Scale

Question	Domain
I would use the conversational agent frequently.	Adoption
I found the conversational agent to be simple.	Usability
I thought the conversational agent was simple and easy to use.	Usability
I think that I could use the conversational agent without the support of a technical person.	Adoption
I found the various functions in the conversational agent were well integrated.	Usability
I thought the conversational agent was consistent in performance.	Usability
I would imagine that most people would learn to use the conversational agent quickly.	Adoption
I found the conversational agent very intuitive.	Adoption
I felt confident using the conversational agent.	Trust
I could use the conversational agent without having to learn anything new.	Adoption
I trust the conversational agent to guide me towards my personal goals.	Trust
I believe the tasks presented within the conversational agent will help me to address my problem.	Trust
The conversational agent would encourage me to accomplish tasks and make progress.	Trust
I agree that the tasks presented within the conversational agent are important for my goals.	Trust
The conversational agent would support me in overcoming challenges.	Trust

The questions of the modified usability scale were recategorized after merging and coaxing language to better fit the scope of the study. The categorization was primarily based on the expected response of the patient using the conversational agent.

Study Procedures

Clinician-researchers asked up to 20 current research subjects in mental health-related studies as they came in for routine study visits if they would like to partake in this conversational agent study. Eligibility criteria were (1) English-speaking, due to language localization issues in development of the conversational agent, (2) 18 years of age or older, and (3) a pre-existing mental health diagnosis. The research staff provided a demonstration of the agent before requesting individuals to partake in the study. The staff then asked open-ended questions, following the script shown in *Table 3*, to assess whether patients understood the nature of the research study and that none of their data would be collected apart from their self-reported scores in the aforementioned scale.

Subjects who agreed were asked to observe and interpret a set of sample results in a printed document of clinical scales about depression, anxiety, and psychosis, and then asked to ask the aforementioned conversational agent (referred to as “chatbot” in conversation) to visualize and interpret the same results, which was programmed to respond in the same way regardless of subject, as explained above. No intervention, exposure, or other unspecified task was presented to subjects; the entire process on average took less than five minutes and subjects were compensated \$5.00 USD for their participation. This study recorded no personal health information, and all responses were stored in a locked and secured facility.

Table 3: Subject Enrollment Script

Personal Introduction	Hello, my name is [research assistant name]. I work with Dr. John Torous, who is running this research study on chatbots in mental health. We are talking because you are partaking in another research study at BIDMC.
About Research Studies	Research is different from routine services and activities like treatment or evaluation you receive in this clinic. Being a research subject is optional and voluntary, and participation will not benefit you directly. Research studies follow careful plans. I can tell you what we plan to do if you decide to take part. When I've explained the study, as outlined in the flyer you may have seen, and answered your questions, you can decide whether you want to be part of the study. Do you have any questions so far? Would you like to see a demonstration of this study with me using the chatbot to ask it to read me values.
About This Study	To ensure you are informed about the study, I will demonstrate myself using the chatbot. [DEMO.] To review again, the purpose of this study is to learn more about how people respond to a chatbot sharing data with them. We expect 50 people to partake in this study and that this interview will take up to 5 minutes. After you try the chatbot, I will ask you to answer some questions about how you found it. All information collected will not be linked to your name or medical history. Do you have any questions about this study? Would you like to hear more so you can decide whether to take part?
More About Participating in This Study	There is minimal risk to partaking in this study, but it is possible information about your opinions on chatbots could be disclosed if there is a mistake or security breach in the study. We think this is not likely to happen, as all results are stored securely on hospital computers, but if

	<p>it did, we do not believe any data could be directly linked to you. There are no direct benefits to you by partaking in this study, but there may be societal benefits in learning how those with mental health conditions see the utility of chatbots. At any time, including now, you can withdraw from the study without negative consequences (that is, without penalty or loss of benefits). To do this, just let me know you want to end. For partaking in the study, you will be paid \$5. Do you have any questions about this study or your participation? Are you ready to decide whether or not to participate?</p>
<p>Informed Consent</p>	<p>If you have any questions, you can contact the study primary investigator, Dr. John Torous at [phone number redacted]. You can also contact Human Subject Protection Office at [phone number redacted]. You have the right to ask questions at any time as well as the right to decline to participate or to withdraw consent at any time without penalty or loss of benefits. Do you want to volunteer to be a subject in this study?</p>

The subject enrollment script is reproduced to detail all disclosures and interactions with the patient that were not conducted by a conversational agent.

RESULTS

Survey Results

The mean score per question is listed below in *Table 4*, with $n = 20$.

Table 4: Mean Scores by Question

Question	Mean Score
I would use the conversational agent frequently.	3.4
I found the conversational agent to be simple.	3.6
I thought the conversational agent was simple and easy to use.	3.6
I think that I could use the conversational agent without the support of a technical person.	3.05
I found the various functions in the conversational agent were well integrated.	3.4
I thought the conversational agent was consistent in performance.	3
I would imagine that most people would learn to use the conversational agent quickly.	3.8
I found the conversational agent very intuitive.	2.95
I felt confident using the conversational agent.	2.75
I could use the conversational agent without having to learn anything new.	3.15
I trust the conversational agent to guide me towards my personal goals.	2.6
I believe the tasks presented within the conversational agent will help me to address my problem.	2.55

The conversational agent would encourage me to accomplish tasks and make progress.	2.75
I agree that the tasks presented within the conversational agent are important for my goals.	2.65
The conversational agent would support me in overcoming challenges.	2.6

The results of the Conversational Agent Usability Scale after means were calculated per question; standard deviation is omitted.

Survey Results Aggregated By Domain

The mean score per domain, which is an aggregate score per multiple questions, are listed in *Table 5*, with the same $n = 20$.

Table 5: Mean Scores by Domain

Domain	Mean Score	SD Score
Adoption	3.27	0.99
Usability	3.4	0.93
Trust	2.65	0.95

The results of the Conversational Agent Usability Scale after means and standard deviations were calculated per domain, consisting of between 4 and 6 questions per domain.

Additional Comments

Additional comments written by subjects, with no relation to the scale itself, are listed in *Table 6*.

Table 6: Additional Comments

Comment
“I am concerned that a robot would not understand my specific needs.”
“I don’t think the chatbot sounds genuine. It sounds like it will steal my credit card.”
“I can’t connect with the chatbot like I would with my doctor.”

Additional comments that patients felt were not represented by any question in the survey.

DISCUSSION

Interpretation of Adoption Domain

As indicated by a mean score per domain of 3.27, subjects typically felt content with adoption and believe that the conversational agent could become commonplace without complicated technical hurdles. The standard deviation further indicates that there was moderate disagreement among subjects in whether or not conversational agents would be easy to adopt, likely due to their perceived ease of use. These results coincide with our understanding of the current technological landscape. Nearly all ^{[3][7]} mobile phones, wearables, and smart home devices are equipped with an internet-enabled conversational agent of some kind, subjects may have already used them for mundane tasks such as maintaining a shopping list or checking the weather before leaving home. In this experiment however, it should be noted that the use of conversational agents in tracking mental health status, progression, and conditions was well accepted.

Interpretation of Usability Domain

With a mean score per domain of 3.4 and standard deviation of 0.93, subjects tended to feel less comfortable than initially expected with the usability of the conversational agent. This could be explained by the simplicity of the agent's interactions as well as the lack of true conversational ability. If a phrase isn't understood by the conversational agent, it replies to the user "Sorry, I didn't catch that," or a similar phrase indicating the user must either repeat the phrase or that the user did not utter a phrase supported by the conversational agent. This type of interaction does not usually occur in human-to-human conversation and thus breaks the illusion of a personality owned by the

agent. Subjects could also be confused by the number of options for accessing and interacting with the conversational agent. In the future, most devices with hot-word detection (supporting “Hey Siri” or “Okay Google”, for example) and a conversational interface will serve as a single hub for interactions with multiple conversational agents, alleviating this fatigue of choice.

Interpretation of Trust Domain

With a mean score per domain of 2.65 and standard deviation of 0.95, subjects felt least content with trusting the conversational agent. It is unlikely that this score indicates an improvement over the baseline. This is a natural response to new technology as well as an imperfect conversational framework that the conversational agent is built on. Usability likely has a direct impact on trust for digital therapeutic tools, and slight inconsistencies in responses or an agent using a voice sounding artificial or robotic could cause mistrust, especially in the healthcare context. Further, in patients with mental illness, other factors caused by the illness itself could inhibit trust.

Interpretation of Additional Comments

All three comments of note relate to the trust domain, with subjects indicating that the conversational agent lacks genuinity and empathy. Furthermore, these two factors likely couple into a chatbot not understanding the specific needs of a patient as a clinician might. As initially noted regarding limitations of the technology used by conversational agents, it may not be possible to mitigate some of these factors related to the trust domain. As natural language processing and artificial intelligence technology improves, strides in contextual understanding of user input as well as more natural speech output should tremendously aid patient trust. Some possibilities include emotional analysis of

spoken input, custom voice models inspired by or made in the image of a particular clinician, or simply the ability to access the agent on any device or platform, as initial examples.

Alternative Domains

Other domains were not considered in clustering of survey questions outside of the domains of adoption, usability, and trust. Though these three convey detail and insight into the previously stated aims for assessing preliminary interest and feasibility of the use of conversational agents in mental health settings, other domains could have been included for understanding conversational agent use from a more healthcare-centric point of view. For example, subjects were not explicitly asked about convenience, tone of voice or content of delivery, or preference of modality (such as between text, voice, or an embodied avatar).

Limitations

A major limitation of the study as conducted was the lack of a demographic pre-survey. Though the survey process was kept brief to manage time constraints and make it simple to participate in the study, collecting demographic information such as age or education level, as well as smartphone device type and specific mental illness diagnosis could inform more specific use-cases of conversational agents. For example, patients with depression or social anxiety may rate the conversational agent higher in the aspect of trust than patients with schizophrenia or bipolar disorder. Furthermore, the sample size was too restricted and the subject population was too localized to a single facility; these factors could influence whether or not individuals had prior access or usage of some technology or education levels.

Modifications to the survey administered could include the addition of other measured parameters or domains (as explained above); a comparison survey to the baseline before interacting with the conversational agent would also suggest whether a subject's existing scope of knowledge or experience with technology was an influencing factor. Once more, in the interest of expediting the study participation, the scope of the survey was intentionally limited and this may limit the conclusions drawn from the data thusly collected.

Conclusions

In summary, though conversational agents are now readily accessible and relatively easy to use, there is a bridge to be crossed before patients are willing to trust a conversational agent compared speaking directly with a clinician in mental health settings. With increased attention, clinic adoption, and patient experience, however, conversational agents could be readily adopted for simple or routine tasks and requesting information that would otherwise require time, cost, and effort to acquire. The field is still nascent, however, and with advances in digital technologies and artificial intelligence, capturing the essence of natural language conversation could transform this currently simple tool with limited use-cases into a powerful one for the digital clinician.

APPENDIX: AMAZON LEX CONFIGURATION

The following configuration file (titled 'lex.json') is reproduced for the purposes of import into an Amazon Lex instance.

```
{
  "metadata": {
    "schemaVersion": "1.0",
    "importType": "LEX",
    "importFormat": "JSON"
  },
  "resource": {
    "name": "LAMPBot",
    "version": "1",
    "intents": [
      {
        "name": "SleepResult",
        "version": "2",
        "fulfillmentActivity": {
          "type": "ReturnIntent"
        },
        "sampleUtterances": [
          "How are my sleep symptoms",
          "How is my sleep",
          "Is my sleep ok",
          "Are my sleep symptoms ok",
          "Am I sleeping well",
          "Sleep"
        ],
        "slots": [],
        "conclusionStatement": {
          "messages": [
            {
              "groupNumber": 1,
              "contentType": "PlainText",
              "content": "It looks like you're not sleeping that well and it
might be affecting your mood or psychosis symptoms. You should get some more
rest at regular hours. Make sure you sleep a full eight hours a night."
            }
          ]
        }
      },
      {
        "name": "PsychosisResult",
        "version": "2",
        "fulfillmentActivity": {
          "type": "ReturnIntent"
        },
        "sampleUtterances": [
          "Psychosis",

```

```

    "Psychotic",
    "Am I psychotic",
    "How are my psychosis symptoms",
    "How is my psychosis"
  ],
  "slots": [],
  "conclusionStatement": {
    "messages": [
      {
        "groupNumber": 1,
        "contentType": "PlainText",
        "content": "Your psychosis symptoms are a little worse than
usual this week and it might be because of your poor sleep. It does seem like
when you exercise and walk more, you feel better."
      }
    ]
  }
},
{
  "name": "MoodResult",
  "version": "2",
  "fulfillmentActivity": {
    "type": "ReturnIntent"
  },
  "sampleUtterances": [],
  "slots": [],
  "conclusionStatement": {
    "messages": [
      {
        "groupNumber": 1,
        "contentType": "PlainText",
        "content": "Your mood has been much better this week! It might
be because you're around family and friends more but also because you're
walking and exercising more this week than you did last week."
      }
    ]
  }
},
{
  "name": "GetDataSummary",
  "version": "4",
  "fulfillmentActivity": {
    "type": "ReturnIntent"
  },
  "sampleUtterances": [
    "How have I been doing today",
    "How have I been today",
    "How am I today",
    "How have I been doing",
    "How have I been",
    "How am I"
  ]
},

```

```

    "slots": [],
    "conclusionStatement": {
      "messages": [
        {
          "groupNumber": 1,
          "contentType": "PlainText",
          "content": "You're doing better today than you did in the past
week. It looks like your mood has improved, you've walked more, and you've
been out with friends and family more often."
        }
      ]
    }
  },
  {
    "name": "Hello",
    "version": "4",
    "fulfillmentActivity": {
      "type": "ReturnIntent"
    },
    "sampleUtterances": [
      "Hello",
      "Hi",
      "Who is this"
    ],
    "slots": [],
    "conclusionStatement": {
      "messages": [
        {
          "groupNumber": 1,
          "contentType": "PlainText",
          "content": "Hi! I'm mind lamp. Ask me about how your mental
health is doing."
        }
      ]
    }
  },
  {
    "name": "AnxietyResult",
    "version": "2",
    "fulfillmentActivity": {
      "type": "ReturnIntent"
    },
    "sampleUtterances": [
      "Anxiety",
      "Anxiety symptoms",
      "How is my anxiety",
      "How are my anxiety symptoms",
      "How am I doing for anxiety",
      "Am I anxious"
    ],
    "slots": [],
    "conclusionStatement": {

```

```

    "messages": [
      {
        "groupNumber": 1,
        "contentType": "PlainText",
        "content": "You were more anxious this week but today seems to
be much better. It could be because you're with family and friends but when
you aren't home often through a day you feel more anxious."
      }
    ]
  },
  {
    "name": "AboutMe",
    "version": "2",
    "fulfillmentActivity": {
      "type": "ReturnIntent"
    },
    "sampleUtterances": [
      "Who made you",
      "Is this research",
      "Are you real"
    ],
    "slots": [],
    "conclusionStatement": {
      "messages": [
        {
          "groupNumber": 1,
          "contentType": "PlainText",
          "content": "I'm a chatbot made by the Beth Israel Division of
Digital Psychiatry."
        }
      ]
    }
  },
  {
    "name": "HelpIndex",
    "version": "1",
    "fulfillmentActivity": {
      "type": "ReturnIntent"
    },
    "sampleUtterances": [
      "What do you do",
      "What do I do",
      "What can I ask",
      "What can I ask you"
    ],
    "slots": [],
    "conclusionStatement": {
      "messages": [
        {
          "groupNumber": 1,
          "contentType": "PlainText",

```

```

        "content": "Try saying "How am I doing today?" or
        "How is my anxiety?" or "How are my psychosis symptoms?".
        I can help you with anxiety, mood, psychosis, and sleep."
    }
  ]
}
],
"voiceId": "Matthew",
"childDirected": false,
"locale": "en-US",
"idleSessionTTLInSeconds": 300,
"clarificationPrompt": {
  "messages": [
    {
      "contentType": "PlainText",
      "content": "Sorry, can you please repeat that?"
    }
  ],
  "maxAttempts": 1
},
"abortStatement": {
  "messages": [
    {
      "contentType": "PlainText",
      "content": "Sorry, I don't know how to help. Try saying "What
do you do?" and I'll tell you everything you can ask me."
    }
  ]
}
}
}
}

```


APPENDIX: RAW POST-USAGE SURVEY RESULTS

The following table contains the raw post-usage survey results excluding additional comments as used by the aggregate scores above.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	3	2	4	4	4	3	3	3	4	2	2	2	3	2
2	3	4	4	4	3	3	3	5	3	3	3	3	3	2
3	3	3	2	3	3	3	2	3	3	3	3	3	2	3
2	4	4	4	4	4	4	3	3	4	2	2	4	3	4
2	3	3	3	2	2	4	3	1	4	3	3	3	2	2
4	4	3	2	4	2	4	4	2	4	3	2	4	2	3
5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
4	2	4	3	3	2	4	2	2	4	2	2	2	2	3
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
4	4	3	4	4	4	4	4	4	2	3	3	3	3	3
2	4	4	3	3	4	4	4	3	4	1	2	2	4	2
3	2	2	2	2	3	4	3	2	2	3	2	2	2	2
4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	4	4	3	2	4	2	2	2	2	1
4	4	4	2	3	2	4	2	2	2	2	2	2	2	2
4	4	4	2	3	2	4	2	2	2	2	2	2	2	2
4	4	4	2	3	2	4	2	2	2	2	2	2	2	2
4	4	4	2	3	2	4	2	2	2	2	2	2	2	2
4	4	4	2	3	2	4	2	2	2	2	2	2	2	2
4	4	4	2	3	2	4	2	2	2	2	2	2	2	2

REFERENCES

- [1] Murray C, Vos T, Lozano R, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*. 2012;380(9859):2197.
- [2] Trautmann S, Rehm J, Wittchen H. The economic costs of mental disorders. *European Molecular Biology Organization Reports*. 2016;17(9):1245-1249.
- [3] Oladeji BD, Gureje O. Brain drain: a challenge to global mental health. *British Journal of Psychiatry International*. 2016;13(3):61-63.
- [4] Demographics of Mobile Device Ownership and Adoption in the United States. <https://www.pewinternet.org/fact-sheet/mobile/>. 2018.
- [5] Topol, E. Health Education England. The Topol Review. Preparing the Healthcare Workforce to Deliver the Digital Future. *Health Education England, editor. London, United Kingdom: NHS*. 2019;1-48.
- [6] Torous J, Friedman R, Keshavan M. Smartphone Ownership and Interest in Mobile Applications to Monitor Symptoms of Mental Health Conditions. *Journal of Medical Internet Research: mHealth uHealth*. 2(1):e2.
- [7] Vaidyam, A. N., Wisniewski, H., Halamka, J. D., Keshavan, M. S., & Torous, J. B. (2019). Chatbots and Conversational Agents in Mental Health: A Review of the

Psychiatric Landscape. *The Canadian Journal of Psychiatry*.

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CURRICULUM VITAE

