

Coerced Change-talk with Conversational Agents Promotes Confidence in Behavior Change

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ABSTRACT

Motivational interviewing is a counseling technique that works, in part, by helping people talk about changing their behavior. We describe two conversational agent-based interventions to increase motivation and confidence to promote physical activity and fruit and vegetable consumption that incorporate principles from motivational interviewing. We also explore the efficacy of constraining input, so users are only allowed to express change talk in their conversation with the agent. In a within-subjects experiment we demonstrate that both interventions are effective at increasing motivation, confidence, and self-efficacy for behavior change during a single counseling session. We also demonstrate that coercing user change talk leads to significantly greater increases in confidence compared to equivalent counseling agents that allow users to express statements about not changing their behavior.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI** •
Applied computing → **Consumer health; Health care information systems**

KEYWORDS

Virtual agents; Motivational interviewing; Attitude; Behavior change; Change-talk; Health; Forced compliance

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1 INTRODUCTION

Motivating people to change their attitudes and engage in healthy behavior is a difficult and important task. The pervasive use of computers and mobile devices paves the way for using software applications as a scalable means to help individuals follow health guidelines and attain their goals. Accomplishing this successfully requires creating interventions that are tailored to the individuals’ characteristics and circumstances [1, 2]. A common method for tailoring is identifying a user’s stage of change using the transtheoretical model of health behavior change [3]. Stage-specific techniques can then be used to motivate people towards behavior change or behavior continuity.

Motivational interviewing (MI) is a counseling method used to enhance a person’s motivation for change [4] and has a variety of techniques that are used at different stages of change. The main goal of MI is for counselors to help their clients resolve their ambivalence about their current behavior and get them to consider behavior change. The counselor elicits this change-talk from clients using particular strategies, such as listing the pros and cons of their behavior, talking about their current level of motivation and confidence to change, and encouraging them to speak freely without being judged.

Given the effectiveness of MI [5], creating systems capable of conducting MI sessions automatically would be beneficial. Embodied conversational agents (ECAs) are virtual agents that simulate face-to-face interactions by having a human embodiment and exhibiting non-verbal behaviors [6], and thus can be a vehicle for driving digital counseling interventions for health behavior change. However, since MI relies on open elicitation from clients, designing automated conversational interventions that implement MI faithfully is challenging [7]. Some researchers have implemented an ECA system that uses a few techniques from MI that work with constrained input, e.g., only allowing users to select what to say from a multiple-choice menu [8], but these are very limited in functionality.

In our current effort, we developed an ECA that promotes two health behaviors—physical activity and fruit and vegetable consumption—using MI to increase motivation and confidence to change. We address these behaviors due to their wide applicability and because most American adults struggle to meet the Center for Disease Control’s general recommendations, e.g., 23% of American adults meet the recommendations for physical activity [9] and more than half of Americans consume less than the recommended daily servings of fruits and vegetables [10].

The ECA makes use of fully-constrained user input to the MI counseling conversation. Rather than being a limitation, constrained interfaces provide opportunities to explore novel methods for bringing about attitude change, for example, by only allowing users to express change-talk at key moments of the session. This approach is based on the phenomenon of *opinion change following forced compliance*, a derivative of cognitive dissonance theory [11] studied in the field of behavioral psychology. Researchers found that people who were forced to

advocate for an opinion they did not hold (e.g., to come up with and rehearse counter-arguments) shifted their private views towards the position they advocated for, particularly when offered low extrinsic reward [12]. In our case, we evaluate the effect of constraining users to only being able to express motivation and confidence in their ability to change or maintain the target health behaviors, compared to a less constrained condition in which they are provided with both positive and negative statements.

To explore these ideas and evaluate the interventions, we conducted a study to address the following research questions:

RQ1: Can we implement an ECA that uses MI techniques to bring about attitude change towards physical activity and fruit and vegetable consumption?

RQ2: Is the agent accepted by users and will they endorse its future use?

RQ3: Does the interaction lead to increased confidence or motivation to change?

RQ4: If we force them to endorse change-talk at key moments in the dialog, does that boost this effect?

2 RELATED WORK

Digital health interventions are increasingly used to promote health behavior change and a growing number of these interventions are implemented based on theoretical foundations. In a review of digital online interventions that promote health behavior change, Webb et al. found that interventions based on theory and those that incorporated more behavior change techniques tended to have larger effect sizes than ones that did not [13]. Among the top theories and behavior change techniques, with respect to effect size impact, were the transtheoretical model and barrier identification coupled with problem solving, an important MI technique.

There have been several attempts to build automated health behavior change interventions that incorporate elements of MI, are deployed using ECAs, or both. One such example is the MAPIT program, which is a web-based intervention to increase motivation for substance abuse treatment among clients in the criminal justice system using illicit substances. The program uses the extended parallel process model, MI, and social cognitive theory in two sessions. The first session aims to motivate clients to complete probation, change their substance use, and obtain HIV care. The second session, 30 days later, focuses on goal setting, coping strategies, and social support. Participants in a pilot test were generally positive about the program's features, felt that it would help them be more successful on probation and in treatment. They appreciated that the system tailored content to them, it could display personal and population statistics, and give them insight into other people's reasons for completing probation [14].

Another research-driven digital intervention combines MI and cognitive behavioral tools to create a self-guided supportive coaching experience for improving the mental health and wellness of its users. The system is a texting platform that leverages artificial

intelligence and natural language technologies to conduct its interactions with users. In a feasibility study, 95% of users reported improvements in their mental wellbeing, though the particulars of how the system uses the counseling methods is not reported [15].

With recent advances in speech recognition and machine learning technologies, using conversational agents for healthcare that allow natural language input has increased; however, their effectiveness remains unclear. In a review of 14 systems that allow natural language input (written or spoken), only one system was found to have a significant effect on participants' health [16]. The same review found that approximately 70% of the conversational agents suffered from problems with language understanding and/or dialog management [16], threatening user safety [17].

Several researchers have evaluated the use of constrained input ECAs and social robots to drive automated MI sessions. Schulman et al. (2011) implemented a model of MI dialog into the dialog manager of an intelligent conversational agent to promote exercise and healthy eating behavior. The model contained adjacency pairs (agent utterance and user options) for each type of MI-specific dialog act that can be enacted depending on the context at any given time in the conversation. In a formative evaluation, users rated the system highly on satisfaction [8].

In an ECA-based intervention delivering a brief MI for reducing alcohol consumption, Lisetti et al. (2013) found that an empathic ECA was rated significantly higher than a text-only system on several measures of usability and user experience, while a non-empathic ECA showed fewer significant results [18]. This finding is congruent with the emphasis that is placed on using empathy in MI [4].

These findings on using MI to promote behavior change through constrained interactions with ECAs and social robots [19] have shown that MI can increase satisfaction and usability of these systems. Our current effort focuses on measuring the effects of an interaction with ECAs on behavior change attitudes and explores the additional effects of being coerced into change-talk.

3 AGENT INTERVENTION DESIGN

We developed two ECA-based interventions to increase motivation and confidence to increase physical activity and fruit and vegetable consumption that incorporate principles from MI. We used two agents, one for each topic: Emily for exercise and Katherine for nutrition (Figure 3).

3.1 Virtual Agent System

The ECAs speak using synthetic voice and exhibit synchronized non-verbal behaviors generated by BEAT [20]. The interaction is driven by a hierarchical task-network based dialogue manager using a template-based approach to agent utterance and user option generation. Users interact with the system by selecting an option from a menu updated at every turn of the conversation (Figure 1). The agent application is built using the Unity3D game engine and

the agent's speech is synthesized using a native IVONA speech synthesizer.

3.2 MI Conversation Design

Unlike other cognitive behavioral approaches, MI is a counseling approach that has been shown to be effective for changing attitudes about diet and exercise leading to behavior change [21] and about drug-related risks among young people following a single brief session [22]. Thus, we modeled the structure of the conversation between our participants and ECAs using the principles and goals of MI most often employed in a brief initial session with a human counselor. In the following section, we describe the integration of specific MI counseling techniques into our automated ECA system (See Figure 2 for examples).

The conversations with our agents follow the same general structure. They begin with a greeting and a bit of small-talk and humor for building rapport. Next, the agents provide participants with standard clinical guidelines for either physical activity or fruit and vegetable intake, depending on which topic the agent is discussing. During this section of the motivational interview, the ECAs ask participants for permission to continue the conversation, a key aspect of MI. If they agree, the agent reflects their willingness to have the conversation using positive affirmational statements, which give the agent an opportunity to build additional trust and rapport with the user. Importantly, the agent emphasizes her role as



Figure 1: The exercise agent, Emily, using a readiness ruler to gauge the participant's readiness to change.

a collaborator, as opposed to an 'expert', working to help participants identify their goals and explore their feelings of ambivalence towards either changing or maintaining the target behavior. Once participants agree to continue the conversation, the agent asks participants if they currently follow these guidelines or not, and tailors the conversation accordingly.

Participants not currently following the health recommendation have a conversation in which the ECA develops discrepancy between their current behavior and the target behavior. For those following the recommendations, the agent continues the conversation focusing on maintaining their current behavior and attempts to resolve any ambivalence that the user may have.

Next, the agent asks participants how important the target behavior is to them using a readiness ruler. Gauging readiness for change allows the agent to validate the participants' current level of readiness and gives users an opportunity to express anxiety or ambivalence (Figures 1 and 2). The agent uses an MI technique called 'simple reflection' to examine participants' specific concerns by verbally rephrasing their selection, giving the participants an opportunity to listen to their own words out loud.

This is followed by the agent asking participants why the target behavior is important to them and they reply by selecting from a list of common reasons for increasing the target behavior. This type of approach, often referred to as 'enhancing motivation,' is essential in MI to strengthen a client's commitment to change. Therefore, we implemented this technique in our system to help increase participants' motivation to change by allowing them to express reasons for change during the conversation with the agent.

Developing discrepancy is a key principle of MI and is an important aspect of an initial or early session [4, 18]. For participants who selected a low number on the readiness ruler, the agent draws

Agent: *On a scale of 1 to 10, where 1 means a healthy diet is not at all important to you and 10 means health eating is very important to you, how important is healthy eating to you?* [Readiness Ruler]

User: 5

Agent: *It sounds like healthy eating is important to you. Why did you choose a 5 and not a lower number? Why is it important to you to eat fruits and vegetables?* [Reflect and Enhancing Motivation]

User: *To be healthy and live longer*

Agent: *Alright, so what I'm hearing you say is that you would eat more fruit and vegetables to be healthy and live longer. That's a great reason. Sometimes it's helpful to think of ways of adding more fruits and vegetables into your daily life. So, if you decided to eat more, how would you do it?* [Reflect and Advise]

User: *Try some new recipes.*

Agent: *So you would try some new recipes in order to eat more fruits and vegetables. Alright, on a scale of 1 to 10, where 1 means that you are not confident at all and 10 means you are totally confident, how confident are you that you could eat healthier if you wanted to?* [Reflect and Assess Confidence]

Figure 2: A sample from a conversation showing the relevant MI techniques in brackets.

attention to the mismatch between readiness to change by reflecting the participant-identified reasons for change.

Next, the agent offers participants suggestions on next steps to incorporate the recommended health behavior change into their lives. Participants select the suggestions that resonate with them, the agent affirms the participant’s choice, and congratulates them.

Change-talk, when implemented properly, can be used to move participants from ambivalence towards the ‘pathway of change.’ When a counselor uses change rulers or asks clients how committed they are to put into practice a target behavior, she invites the participant to recognize their strengths as well as celebrate their self-efficacy. In the latter part of the conversation, the agent asks users their current level of commitment, motivation and confidence for change. By allowing participants to talk about change, the agent is increasing the likelihood of a positive outcome and continues using simple reflection as a method of expressing support.

Throughout the session, the ECA employs simple reflection to express empathy as well as emphasize the positive aspects of the participant’s current attitudes. While the agent advises participants using clinical recommendations, praise as well as reflective listening allow the agent to move away from “expert” status into a helper role, leaving behind the traditional paternalistic roles typically assigned in therapy. By becoming a partner in the change process, the focus of the session is the client and his or her current state. The agents in our system were designed to provide clinical expertise coupled with empathetic, patient-focused language that lies at the center of MI interventions.

Finally, at the end of the conversation the ECA summarizes the participant’s goals, reasons for change, level of commitment, and

current level of motivation. This kind of summarization is often used at the end of an MI session where the counselor purposefully reflects positive aspects of the discussion. Such therapeutic practices reinforce the client’s motivational statements to promote change.

4 EVALUATION STUDY

To address our research questions, we conducted a one-factor counterbalanced within-subjects pretest-posttest experiment in which participants conducted a single brief counseling session with an ECA. For all conditions, we assessed change in attitudes about the target behavior before and after the intervention. The within-subjects manipulation had two conditions: one restricting participants to choose only positive options when they are asked to express their confidence and motivation levels (Coerced), and the other providing a range of both positive and negative options (NotCoerced). Figure 3 shows an example of the user being asked about their level of motivation towards a particular behavior, with a user menu as it appeared in the Coerced condition (left) and the NotCoerced (right). The treatment order and the association of manipulation with ECA and specific health behavior (exercise or nutrition) were counterbalanced.

4.1 Participants

Participants were recruited through an online advertisement. To be eligible for participation, they had to be at least 21 years old, able to speak and read English, and self-report in a phone screening interview to being in one of the three first stages of change (“precontemplation”, “contemplation”, or “preparation”) [3] for both target behaviors.



Figure 3: On the left, Katherine talks about nutrition and forces the user to choose a positive option. On the right, Emily talks about exercise but allows the user to respond positively and negatively.

Measure	Before - M (SD)	After - M (SD)	Wilcoxon signed-rank
How confident are you that you could reach or maintain this level of fruit and vegetable consumption if you wanted to?	5.44 (1.59)	6.18 (1.02)	W=58.5, p<.05
How motivated are you to reach or maintain this level of fruit and vegetable consumption?	5.73 (1.5)	6.31 (0.83)	W=35, p<.05
Self-efficacy – Nutrition	3.98 (1.36)	4.25 (1.44)	W=135, p<.05
How confident are you that you could reach or maintain this level of physical activity if you wanted to?	5.69 (1.32)	5.74 (1.14)	W=40, n.s.
How motivated are you to reach or maintain this level of physical activity?	5.69 (1.22)	6.0 (0.97)	W=40, p<.05
Self-efficacy – Exercise	4.0 (1.19)	4.53 (1.36)	W=99, p<.05

Table 1: The changes in motivation, confidence, and self-efficacy before and after the intervention, across conditions.

4.2 Measures and Procedure

We randomly assigned each participant a number corresponding to one of four possible configurations of topics and treatments. Following randomization, each participant was asked to consent to participating and filled out a demographics questionnaire. Prior to the conversations with the agents, we assessed the participants' confidence and motivation using single item questions (Table 1), as well as using validated questionnaires to measure self-efficacy [18, 19], decisional balance [21, 22], and stage of change [3] with respect to the health behaviors (exercise or nutrition). These measures were then repeated following each of the two conversations. Additionally, we asked participants to rate their experience of the agents after interacting with each of them using a variety of single item measures (Table 2).

The participants interacted with the ECAs running on an HP touch-screen tablet running Windows 10. They wore headphones and were instructed to touch the options that appeared on the screen to converse with the agent. A message asking them to notify the

research assistant was displayed on the screen once the conversation was over.

The session concluded with asking the participants which agent they would prefer to interact with for a hypothetical third conversation, followed by a short semi-structured interview where participants discussed the experience interacting with the agents, as well as how their motivation and confidence to increase physical activity and/or increase fruit and vegetable intake was affected.

The interviews consisted of a series of open-ended elicitation questions about the participants' overall impressions and being asked to describe each of the two sessions and agents. Additional questions focused on specific aspects of the session, capturing participants' likes and dislikes, their perceptions of the credibility and persuasiveness of the agents, their future intentions to use the systems, and the perceived benefits of the system if widely implemented.

The interviews were audio recorded and transcribed verbatim and analyzed using NVivo 12 software. Coding and analysis followed an iterative process where new codes were added and refined.

Item	Anchor 1	Anchor 2	Mean (SD) - Wilcoxon signed-rank
How satisfied are you with the agent?	Not at all	Very satisfied	Nutrition: 5.8 (1.2) W=78, p<.05 Exercise: 5.7 (1.2) W=175.5, p<.05
How much would you like to continue working with the agent?	Not at all	Very much	Nutrition: 5.7 (1.2) W=117, p<.05 Exercise: 5.7 (1.1) W=177, p<.05
How much do you trust the agent?	Not at all	Very much	Nutrition: 5.6 (1.1) W=136.5 Exercise: 5.7 (0.9) W=78, p<.05
How much do you like the agent?	Not at all	Very much	Nutrition: 5.8 (1.1) W=78, p<.05 Exercise: 5.9 (1.1) W=97.5, p<.05
How knowledgeable was the agent?	Not at all	Very knowledgeable	Nutrition: 5.9 (1.1) W=117, p<.05 Exercise: 5.8 (1.0) W=117, p<.05
How natural was your conversation with the agent?	Not at all	Very natural	Nutrition: 4.9 (1.5) W=351, p<.05 Exercise: 5.0 (1.4) W=331.5, p<.05
How would you characterize your relationship with the agent?	Complete stranger	Close friend	Nutrition: 4.1 (1.4), n.s. Exercise: 4.2 (1.5), n.s.
How similar do you feel that you are to the agent?	Very different	Very similar	Nutrition: 4 (1.7), n.s. Exercise: 4.2 (1.6), n.s.

Table 2: The single 7-point Likert scale items measuring aspects of the agent interaction. The final column shows results comparing participant ratings on these measures to neutral, across conditions.

Common patterns that emerged during data analysis were discussed and grouped into themes.

5 RESULTS

We recruited 39 participants for our study. Their average age was 24.6 (SD=1.9), 55% were female, and the majority were college students.

5.1 General Agent Intervention Results

There was a general positive effect of the intervention on our main outcome measures. Following the conversation about nutrition, participants showed a significant pre-post increase in confidence, motivation, and self-efficacy to eat the recommended daily amounts of fruits and vegetables (Table 1). Additionally, following the conversation about physical activity, participants showed a significant pre-post difference in motivation and self-efficacy to exercise at least 30 minutes a day (Table 1). The pre-post difference in the stage of change and decisional balance measures were not significant.

Following each of the two conversations, participants rated the agents on a variety of single item measures. Their ratings of satisfaction, trust, wanting to continue working, likeability, naturalness, knowledgeable, and conversation naturalness with the agent were significantly greater than neutral for both interventions (Table 2).

5.2 Qualitative Agent Intervention Results

Following the method of grounded theory [28], we analyzed the transcripts from the interviews, resulting in a code book of 44 codes, yielding the following four themes.

Agent attributes and their effects on persuasiveness. During the semi-structured interview, participants described both agents as ‘friendly’, ‘informative’, and ‘trustworthy.’

[P8] *“She was good at communicating, and really she was friendly, and I did not feel ... And I think I could trust her, so I did not feel that she was not trustworthy. So, I think I felt like I was talking to a human being.”*

Additionally, participants reported that the agents appeared to have human-like qualities, displaying non-verbal behaviors such as eye gaze, head nods, and gestures, making the sessions seem both comfortable and natural. Subsequently, participants assigned social roles to both agents, describing them as ‘counselors’, ‘teachers’, or as ‘virtual friends’. A pattern emerged during our analysis where participants who expressed positive attitudes towards the agents also found the agents more persuasive. Participants specifically asserted that social chat used in the beginning of the sessions, coupled with the information delivered during the first component of the motivational interview, increased the persuasiveness of the agents.

[P2] *“One thing I noticed, which was different, was they started with a mild conversation like, ‘How was your day? How did you reach here?’ So, it was not like giving a lecture or starting like, ‘You are doing this, it's wrong. You have to start eating or exercising.’ It makes you listen more. It makes the conversation more natural. It makes you more open.”*

[P11] *“I think that's the reason I think ... I don't know. They're friendlier in a way and like a normal person. Be like, ‘Hey. How are you? How's your day?’ Instead of automatically diving in. They're trying to start a conversation like a normal human being would.”*

[P14] *“Because there were more conversations happening. More or less it was ... I was learning something from it. And somebody was not pushing me for something. I was actually learning from my own end.”*

While most participants enjoyed interacting with both agents, some felt that the sessions were too factual and academic in nature. These same participants mentioned that they found both agents to be ‘a little robotic’.

Benefits of an ECA exercise/nutrition counselor. The majority of participants described both sessions as interactive and conversational, stating that they had never interacted with an agent before on a health topic and further described the interaction as novel and interesting. Some reported that the sessions felt like an interview, while others said they were similar to an academic presentation. In general, participants enjoyed the sessions and reported learning new information that they looked forward to implementing into their daily lives. When asked how the system compared to that of similar interaction with a person, most participants stated that they would actually prefer to talk to one of the agents. These same participants stated that interacting with the agents could provide more frequent opportunities to discuss health topics.

[P22] *“It was easy because you don't really need to go and make an appointment and talk to a person.”*

All participants endorsed both agents, stating that not only was the content valuable but the way in which it was delivered was ‘judgement-free’, ‘safe’, and done in a ‘sensitive and caring manner’.

[P35] *“So whatever you say to them, you're not worried about how they view you and that can be a good thing. It doesn't judge you...I was more honest.”*

Some participants still did not feel fully committed to change but stated that they learned new information that could help them increase their fruit and vegetable intake and/or physical activity. Participants stated that such an intervention, if implemented, could serve as a reminder in a non-medical context.

[P34] *"No, it wasn't uncomfortable. This was a good experience. I mean, I used to exercise, I had been exercising but then I stopped it, so it's kind of reminded me that, 'Yeah, you should go back to yourself, go back to being fit and all that.'"*

Attitudes towards an MI ECA counselor. Overall, participants accepted both agents as counselors. Participants reported during the interview that they felt more confident and motivated after talking with both agents, citing specific components of the motivational interview as possible reasons for this change. Techniques used in initial sessions with human MI counselors were articulated by our participants after their sessions with both agents. For example, participants described the sessions and emphasized that, instead of pressuring, the agent acted as a partner, providing both supportive and directive communication. Several participants admitted feeling resistant to change at first; however, this feeling subsided when the agent started the conversation by asking questions about the participants' current level of readiness, as well as the user's feelings about implementing a change, instead of simply giving a recommendation.

[P16] *"She first introduced herself, then asked me how I was doing, and explained the benefits of exercise, and all. She asked me how motivated I was, and how I felt about not exercising, and what it could do to my health. So, it was a nice."*

[P22] *"She asked us first if you are interested in that and why you are not interested so it was a good one. No pressure. Just listened."*

Participants articulated the importance of both the agent presenting them with new tips for implementing the behavior, as well as highlighting novel benefits of changing. Both strategies are common practice in early sessions of motivational interviewing, where a counselor will adjust and tailor the conversation based on the client's current commitment level and goals [4].

[P23] *"So, she was asking me how motivated I am to work out, why I want to work out, what do I want from working out, how confident I am. And then she spoke to me about how often I should exercise and how modern exercise should be. And how I can incorporate it ... She gave those few tidbits like, you can ... I'm trying to remember. You can park the car further away and you can walk up. These are things that I probably don't think about. I just park my car right opposite north east and then I walk through. But now that I think about it, I'm like, 'Yeah, why don't I do that?' It's an additional few steps but it still gives me some form of exercise."*

MI counselors are careful to present new information in such a way as to elicit change talk and promote behavior change, as well as making sure that she acts in partnership with clients by resisting confrontation and affirming that the decision to change is ultimately the client's. This communication style was present in our systems and mentioned by our participants as empowering.

[P16] *"She told me that it is entirely my choice to exercise or not, but she did show the benefits regardless. She didn't pressure me towards exercise, but then she was conveying that is better if I do."*

Participants also responded well to our agent's use of simple reflections to enhance motivation. Multiple participants pointed out that the agent's ability to respond to input options selected by users was not only powerful but enhanced their willingness to change.

[P10] *"She went into depth in the importance of it and based on the answers that I chose I felt like it wasn't just a straight conversation ... I felt like a connection, but, yeah, in a way like a connection because her responses were based off what I was answering too."*

[P9] *"So, yeah, she is trying to make me remember things, what was the conversation that we had earlier. I made good choices, good health choices, so she wanted me to remember the same things again. Keeping me more diligent for having healthy choices and getting me motivated."*

One participant mentioned that summarizing what was previously discussed, as well as repeating back to her the change in physical activity she had agreed to using, was a salient moment that helped increase her motivation. Summarization is used as a tool during MI to both reinforce the client's choices and demonstrate to the participant that the counselor has been listening [4].

[P3] *"It was very easy to talk to them. The one thing I liked at the end of each conversation was that they recapped your choices for you, and so that was really helpful to just kind of summarize. It got me thinking."*

Suggested improvements. Participants offered suggestions to improve both agent systems, such as tailoring the conversation based on user characteristics like height, weight, and sex, as well as previous physical activity and nutrition history. Some participants felt that personalization would increase the effectiveness of the interventions. Other suggestions included improving the fluidity of the agents' movements and voice to potentially increase naturalness. Finally, participants expressed a desire for continued longitudinal interactions, stating that continuing the conversation with the agents could help them reach their goals and could assist them in improving their overall physical health and wellbeing.

5.3 Coerced Change-talk Experiment Results

Evaluating the outcomes of our within-subjects manipulation yielded some significant results. Participants in the Coerced condition had a significantly higher change in confidence with respect to performing the desired behavior than those in the NotCoerced condition (Figure 4 & Table 3). A further analysis, looking only at the conversation with the nutrition agent, revealed that participants in the Coerced condition reported higher changes in confidence compared to the NotCoerced condition (Table 3). When asked which agent they would like to interact with for a hypothetical third conversation, a significantly greater number of

participants chose the agent in the NotCoerced condition than in the Coerced (Table 3).

No other measures were significantly different between the Coerced and NotCoerced conditions.

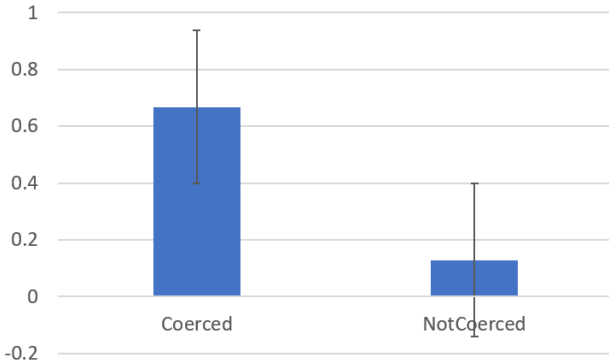


Figure 4: Increase in confidence during the intervention was greater in the Coerced condition than the NotCoerced.

Measure	Forced M (SD)	NotForced M (SD)	Statistical test
Δ Confidence	0.67 (1.5)	0.13 (1.0)	W=223.5, p<.05
Δ Confidence - Nutrition	1.45 (1.6)	0 (1)	W=307.5, p<.05
Agent Choice	11	28	X ² (1)=7.4, p<.05

Table 3: Measures that showed a significant difference between the Coerced and NotCoerced conditions.

5.4 Qualitative Coerced Change-talk Experiment Results

Differences between nutrition and exercise agents. Some participants preferred one agent to the other; however, these preferential differences did not seem to be related to being coerced into expressing change talk. Instead, various reasons for participant preference were related their sense of humor, topical interest, and perceived difficulty in implementing the behavior.

Both agents began each conversation with a few turns of social chat that included a joke. Preference for certain jokes was a common theme that emerged during our analysis. When asked which agent/conversation was preferred, many users consistently stated that the nutrition agent was more relatable and funnier, citing specifically a joke that she told.

[P5] *“Yeah, she was a lot more fun to talk with. She was kind of making jokes and all. It was related to weather like this. She seemed friendlier.”*

[P23] *“I was really intrigued when I first met her. And it was exciting to see her talk about Boston and being interactive. Her*

jokes. And trying to make that connect. That was very interesting. It made her more relatable.”

Participants also preferred one of the agents over the other depending on the health topic being discussed. For example, some participants reported that they were more interested in nutrition as opposed to exercise making that respective agent their favorite.

[P12] *“Because I’ve been excited for a lot of nutrition, I don’t know much about [it]. So, I would like to gain more information about nutrition, food. So, the first agent I want to talk to more.”*

Other participants mentioned that exercising seemed more difficult and thus preferred and felt more motivated when speaking with the nutrition agent.

[P38] *“Exercise was a little bit difficult to do. Fruits and vegetables seem easier. I like to eat.”*

Lastly, some participants found the agent that shared new information with them more interesting.

[P3] *“I guess I just remember actually Emily more about like exercising. Just talking about being very motivated and yeah. I think there are more options for why you should want to exercise, like I mentioned the sex life benefit I didn’t know that.”*

Acceptance of coerced change talk. When asked directly if they noticed anything different between the agents or the sessions, most participants struggled to identify any differences. While they recognized that the substantive content of the conversations was different, they felt that overall the agents were similar. While improvements were suggested, none of the participants mentioned wanting to end the session and none highlighted the coerced change talk input choices as a reason to decline future use of either system. As obtrusive as we thought our manipulation of the input options could be, all participants found the manipulation relatively subtle. In fact, the majority of our participants either did not find the coerced change talk frustrating or did not seem to notice it.

[P23] *“I liked her because she told me I was really committed, and then also because I think the summarizing part. I mean, I don’t know what it is. But my experience with Emily was better than my experience with Katherine. Maybe just that’s why.”*

Only one participant stated that one agent had only included positive options for the her to select. However, she felt that these restricted input options were actually due to the agent caring about her, thereby actively encouraging the participant to use self-motivational statements by offering only change talk.

[P9] *“Both of them seemed pretty similar, but the second agent, I guess, because during the end of the conversation, I think, she answered most of my questions. But her, the options I was getting*

were limited, so I think she was trying to make me realize what I wanted to do, again...I liked that.”

When asked directly, none of the participants felt that either agent was coercive or manipulative.

6 CONCLUSIONS

Overall, both interventions were effective at changing motivation, confidence, and self-efficacy to change physical activity and fruit and vegetable consumption behavior. Satisfaction with the agents and interventions was high, as evidenced in both quantitative and qualitative self-reports. Conversational agents can effectively implement aspects of motivational interviewing to help individuals increase their motivation and confidence to the point where they are willing and able to take action.

Our manipulations also demonstrated that constraining user input to change talk was effective at further boosting confidence in general, particularly for nutrition promotion. For physical activity promotion, these differences were not significant, but motivation in general was trending in favor of constraining user input to bring about change-talk. Importantly, there was no significant decrease in satisfaction when input was constrained, nor did participants seem to notice the manipulation beyond the observation that they were limited in what they could say; an issue raised equivalently for all study conditions. That said, even though they were mostly unaware of the manipulation, a significantly greater number of participants said that in a future interaction they would prefer interacting with an agent that did not try to coerce change-talk, given the choice. However, since there were no differences in their willingness to continue working with either agent, participants' preferences for future interactions may be influenced by other factors.

6.1 Limitations

The study has some limitations. We used a small convenience sample comprised mostly of students at an American university, which may not be representative of the general population and cultures outside the USA. In addition, while we did attempt to demonstrate generality of efficacy of motivational interviewing and constraining user input to change talk by demonstrating them on two health behaviors, they may still not generalize to all health behavior change interventions. Results from our single counseling sessions may not persist in the context of a longitudinal intervention. Finally, although associations between psychological constructs such as motivation, confidence, and self-efficacy and actual behavior change have been demonstrated in many studies [20–22], our study did not follow through to determine whether the interventions would lead to improvements in physical activity and diet behaviors.

6.2 Future Work

Future work includes the automation of a wider range of motivational interviewing techniques in a conversational agent.

This is particularly challenging given the open-ended nature of client responses typically elicited during such sessions, and the safety concerns over doing automated health counseling with unconstrained input [17], but represents an important direction of future research. Investigating additional techniques for automatically eliciting user change talk is also an important direction of research.

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