

An Intelligent Conversational Agent for Promoting Long-term Health Behavior Change using Motivational Interviewing

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Abstract

We present a conversational agent designed as a virtual counselor for health behavior change. The agent incorporates techniques drawn from Motivational Interviewing to enhance client motivation and confidence to change; these techniques are modeled and implemented based on a domain-specific taxonomy of dialogue acts. We discuss the design and preliminary evaluation of the agent.

Introduction

People who could benefit from a positive change in health behavior form a large and variable population, with differences in individual characteristics and circumstances. If automated interventions are to be effective on a large scale, they must be designed to accommodate as wide a range of individual differences as possible, and research should work to identify and address individuals who may represent a challenge for existing interventions.

The transtheoretical model of health behavior change identifies several stages of behavior change which individuals may pass through (Prochaska and Marcus 1994), and predicts that different intervention techniques will be effective in different stages. Individuals in the earliest stages – “precontemplators” and “contemplators” – do not admit to intention or willingness to change; precontemplators do not admit to actively considering behavior change. Precontemplators and contemplators may know of many valid reasons for change, but may still have difficulty making a first step toward change. These individuals are challenging to assist, and have not received much attention in the literature on automated health behavior change.

Motivational Interviewing (MI) is a brief, directive, client-centered counseling method for enhancing intrinsic motivation to change by prompting clients to explore and resolve ambivalence (Miller and Rollnick 2002). MI has been applied to health behaviors including physical activity

promotion (Harland et al. 1999) and diet modification (VanWormer and Boucher 2004), and has been identified as a particularly effective mechanism which health care providers may use to assist precontemplators and contemplators (DiClemente and Velasquez 2002).

We have developed an automated counseling system in which clients interact with an embodied conversational agent (Cassell 2000) that acts as a virtual counselor. To assist users who are in the precontemplation and contemplation stages of change, our system incorporates techniques drawn from Motivational Interviewing. We focus on a set of conversational strategies designed to elicit “change talk” from clients – statements that indicate motivation and/or confidence toward behavior change.

A goal of our system is to enable reusable and extensible automated behavior change interventions, allowing interventions to be easily modified to support additional target behaviors, for example. With regard to strategies drawn from Motivational Interviewing, a key challenge for reusability – and the focus of this paper – is representing the structure and meaning of MI-inspired dialogue with abstractions that allow the authoring or generation of reusable and extensible content. Our approach is based on a domain-specific taxonomy of dialogue acts, which partially model how a counselor trained in MI might interpret and respond to a client’s utterances.

Related Work

Bickmore and Giorgino provide a review of work in health dialogue systems (Bickmore and Giorgino 2006). However, few of these counseling systems use MI techniques, and none that we are aware of rely on a deep semantics of MI utterances.

1. I: Good morning. Please have a seat here. I believe you wanted to talk about some concerns with your drinking... perhaps you could start by telling me what your concerns are.
2. C: Well, to tell you the truth, I'm not really sure there's anything to be concerned about. My wife seems to think that I drink too much. My doctor did some blood tests... I told her I would come here, but I'm not really sure if I should be here.
3. I: So at least two other people, your wife and your doctor, have been worried that maybe alcohol is harming you. But I wonder: What have you noticed yourself? Is there anything that you have observed about your drinking over the years that might be reason for concern? Tell me something about your drinking.
4. C: I guess maybe I drink more than I used to...
- ...
5. C: I don't like not remembering things.
6. I: That's doesn't seem normal to you.
7. C: No. But I don't think I'm an alcoholic. I've known some alcoholics, and I'm not like that.
8. I: Your situation doesn't seem so bad to you.
9. C: No it doesn't. I've quit drinking for weeks at a time with no problem. And I can have a couple of drinks and leave it alone. I have a good job and family. How could I be an alcoholic?
10. I: That must be confusing to you, as you think about it. On the one hand, you can see some warning signs that you are drinking too much, and it worries you. On the other hand, you don't really fit your picture of an alcoholic.
11. C: Right. I mean I've got some problems, but I'm not a drunk.
12. I: And that's why thus far it hasn't seemed like you needed to do anything. But now you're here. Why now?
13. C: It just seemed like I ought to talk to somebody. I don't want to ignore this. I saw what happened to my dad, and I don't want that to happen to me and my family.
14. I: Your family is really important to you.

Figure 1. Fragments of a MI dialogue (from Miller and Rollnick 2002; pp.141-145). I=Interviewer, C=Client

Features of MI Dialogue

The Motivational Interviewing approach to counseling encourages a counselor to use a style of dialogue in which the counselor rarely offers arguments, or explicit information or advice to the client. Instead, the counselor's goal is to elicit statements of the client's existing beliefs, with the aim of helping the client to notice discrepancies between his or her stated beliefs and values, and his or her current behavior.

Figure 1 shows a series of excerpts from dialogue between a client and a counselor trained in Motivational Interviewing (adapted from (Miller and Rollnick 2002)). The counselor's utterances in this example are often a kind

of *reflection*: a repetition of the contents of the previous utterance by the client, usually restated with a different surface form.

The counselor responds to each client utterance as a statement about the client's motivation and confidence toward behavior change. Utterances that do not appear to be indications of positive change are often treated as *resistance*: an indication of a lack of motivation or confidence in behavior change, and a negative reaction to a counselor's attempts to elicit positive statements (Moyers and Rollnick 2002). In this example, the client states initially that he is not sure he wishes to have this conversation (line 2); the counselor treats this as resistance, rather than as a stated desire to end the interaction. Other possible manifestations of resistance include attempts to shift topics, or refusal to answer.

The client often makes statements that appear to express ambivalent or inconsistent beliefs. Statements that acknowledge the existence of a problem and reasons for change (lines 4, 5, 13) coexist with, and are interleaved with statements that minimize or deny a problem (lines 7, 9, 11). The counselor's responses assume that the client can hold these different beliefs simultaneously, even acknowledging the ambivalence (line 10).

A Semantics for MI Dialogue Moves

We represent Motivational Interviewing dialogue with a domain-specific taxonomy of dialogue acts that focuses on the information a trained counselor might use in order to respond to client utterances. As discussed above, the counselor focuses on eliciting and responding to client statements about motivation and/or confidence. All dialogue acts in our taxonomy share a common set of features, which together describe such statements:

Valence. Statements may be either *change talk*, indicating motivation and/or confidence toward change, or *resistance*, indicating a lack of motivation and/or confidence.

Category. *Status-quo implication* and *change implication* are statements that reference positive or negative aspects of the client's current situation or potential new situation, respectively. Both categories are indicators of (lack of) motivation. *Change outlook* includes statements indicating (lack of) confidence in behavior change, and *change intention* indicates intention, plans, or preparation for change.

Content. The particular topic, concern, or value expressed in a client's statement.

Currently, the only type of dialogue act by a client that we model is a statement consisting of the three features given above. In a particular client statement, some features may be missing or unspecified. For example, a client may respond to a question about behavior change by attempting to shift topics; this dialogue act would be represented as resistance with no specified category or content.

The set of dialogue acts by the counselor that we represent includes acts intended to elicit client statements, and acts which respond to client statements. Thus, these

A: What might be different if you exercised regularly?	Evocative Question Change Implication
U: My health might be better.	Change Talk Change Implication Health
A: Tell me more. What do you think will be better about your health if you exercise more?	Elaboration Request Change Talk Change Implication Health
U: Well, I probably won't lose weight.	Resistance Change Implication Weight
A: You're not convinced that exercise would help you lose weight.	Reflection Resistance Change Implication Weight
U: Yeah.	
A: Okay, let me just summarize what we've been talking about.	
A: You don't know if exercise would help you lose weight.	Summarize Resistance Change Implication Weight
A: On the other hand, if you did start exercising, it might improve your health.	Summarize Change Talk Change Implication Health

Figure 2. Samples of implemented MI dialogue and semantics. A=Agent, U=User.

acts also focus on client statements, and share the same features. This is not intended to be an exhaustive list of techniques used in Motivational Interviewing, and merely includes techniques currently used in our system.

Evocative Question. An open-ended question, designed to elicit client statements, and usually targeted at a specific category. E.g., “Suppose you started exercising regularly tomorrow. What might be different in your life?”

Elaboration Request. A prompt for additional statements, either generically (e.g., “I see. Tell me more.”), or specific to a category and target behavior (e.g., “Tell me more. What kind of trouble do you think you would have with an exercise program?”).

Reflection. A restating of the client’s previous statement, often reworded by the counselor.

Acknowledge Importance. A statement that the value or concern mentioned in the client’s statement is of importance to the client.

Summarize. A restatement of client statements, often combining and juxtaposing several statements.

Implementation

We have implemented this model of Motivational Interviewing dialogue using the LiteBody server/client framework for web-deployed virtual agents and the DTask dialogue manager (Bickmore, Schulman and Shaw 2009). DTask is a dialogue manager designed for system-directed

<p>task Reflection</p> <p>input parameters: behavior, talk_valence, talk_category, talk_content</p> <p>output parameters: valence, category, content</p> <p>adjacency pair:</p> <p>precondition: applicable when behavior='exercise' and talk_valence='change_talk' and talk_category='status_quo_implication' and talk_content='stress'</p> <p>agent utterance: You sometimes feel like you have too much stress.</p> <p>user utterance: If I did exercise, it might be better. valence ← 'change_talk' category ← 'change_implication' content ← 'stress'</p> <p>...</p>
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Figure 3. Example recipe for MI dialogue.

dialogue with restricted input. It models dialogue as a hierarchical task decomposition, and is based on the ANSI/CEA-2018 standard (Rich 2009), with dialogue-specific extensions. A counseling session is represented by a top-level task which is decomposed, using a library of recipes, into subtasks, each encompassing a distinct portion of the session (e.g., greeting, counseling, farewell).

DTask’s atomic tasks – each comprising a single turn of dialogue – are based on the notion of “adjacency pairs” (Sacks, Schegloff and Jefferson 1974), a pair of logically related utterances. A turn of dialogue is represented by an adjacency pair template, including an agent utterance and a list of possible user utterances. There may be an arbitrary number of adjacency pair templates for a particular task, which may be selected by applicability conditions. The surface form of agent and user utterances are natural language utterances, but may include variables to be filled in at runtime (template-based text generation).

Our model of MI dialogue was implemented in DTask by defining a task for each type of agent dialogue act, such as Reflection. For each such task, we then define a large number of adjacency pairs, each specific to some combination of features of the client statement that the task is intended to respond to or elicit. In addition, a small set of higher-level tasks determines which MI technique the agent should use at a given point in the conversation.

We first implemented with this system an intervention designed to promote physical activity, containing over 400 manually-authored adjacency pair templates related to MI. The system was then extended to promote fruit and vegetable consumption, requiring an additional 600 adjacency pairs related to MI. However, the representations developed here allowed us to reuse nearly all of the higher-level recipes in the system, and this extension was completed in 10% of the time required for the original system.

Group	Assessment	Dialog 2	Dialog 3
Exercise	Expert/Empathy	5.33 (1.15)	6.00 (1.00)
	Expert/MI Spirit	5.00 (1.00)	6.00 (1.00)
	User/Satisfaction	5.57 (1.07)	4.92 (1.43)
Diet	Expert/Empathy	6.00 (0.00)	5.50 (0.71)
	Expert/MI Spirit	5.00 (1.00)	6.00 (1.41)
	User/Satisfaction	5.15 (1.19)	5.04 (1.53)

Table 1. Expert and user evaluations of an agent using MI dialogue (mean (SD); all ratings on 7-point scales).

Evaluation

As part of a formative evaluation of the automated counseling system, two separate groups of participants interacted with a conversational agent interface, making their contributions via touch-screen from a multiple-choice menu. The first group (N=8, ages 21-41, 75% female) received counseling in the domain of exercise promotion, while the second (N=9, ages 22-68, 78% male) were counseled in the domain of fruit and vegetable promotion. Each participant had three conversations with the agent, and was instructed to act as if a day had passed between each conversation. The first conversation was an orientation, with MI dialogue in the second two.

An expert trained in MI counseling, and not involved in the design of the system, provided evaluations of a subset of participant conversations, assessing empathy and fidelity to MI using a standard instrument (Moyers et al. 2005). Participants rated overall satisfaction with the agent following each conversation, using a set of 3 rating-scale items (Cronbach's alpha 0.88).

Table 1 gives descriptive statistics of the results. The expert ratings, in particular, were surprisingly high.

Future Areas of Research

The implementation of MI dialogue developed here is currently being evaluated (as part of a larger counseling system) in a 4-arm, 60-day trial, comparing interventions targeting physical activity and fruit and vegetable promotion with a non-intervention control and with a joint intervention that targets both behaviors.

Our taxonomy of dialogue acts is sufficient to represent only a fragment of the meaning a trained counselor might take from a client utterance, and finer detail could be added. For example, clients may use different forms of resistance, such as arguing, interrupting, and negating (Chamberlain et al. 1984). Similarly, statements classified as change talk may differ in strength; these differences can be predictive of outcomes (Amrhein et al. 2003).

Finally, the manual authoring of a large number of adjacency pairs, covering a sufficiently broad range of topics in MI dialogue, represents a substantial implementation effort, and future work could examine the use of natural language generation in this area.

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