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User interactions with an affective nutritional coach ☆

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ABSTRACT

This paper investigates how users respond to emotional expressions displayed by an embodied agent. In a between-subjects experiment ($N = 50$) an emotionally expressive agent (simulating the role of a nutritional coach) was perceived as significantly more likeable and caring than an unemotional version. Feedback from participants also revealed detailed insights into their perceptions of the agents and highlighted a strong preference for the emotionally expressive version. Design implications for embodied agents are discussed and future research areas identified.

1. Introduction

The use of embodied agents to assist people with changing behaviour is a relatively new research space, and as a result, there are a number of important areas that still require thorough investigation. One such area is the influence that emotional expression has on therapeutic and behaviour change outcomes. Research in (human) therapist–client interactions has highlighted a strong correlation between the working alliance – the relationship between a helper and client – and the therapeutic outcome (Martin et al., 2000). The literature often cites the building of trust and rapport, along with appropriate expressions of empathy, as being essential to building a strong working alliance. A number of research studies have found that the affective displays of a helper in a professional relationship can potentially have a strong influence on the client's perceptions of them, and in turn, the quality of their working alliance. High emotional intelligence is therefore a prerequisite for professional helpers when attempting to help clients achieve their desired goals.

It is known that people have a tendency to treat media and embodied agents as social entities, a fact first expounded in the seminal work of Reeves and Nass (1996). If we treat these agents as real social entities this would suggest that the social behaviours (in particular emotional ones) that facilitate interaction between people would also be useful in supporting interaction between users and embodied agents. Considering the health domain, this suggests that the emotional expressions of embodied agents that simulate behaviour change professionals could also have a strong influence on client perceptions. However, we still have a superficial understanding of how we respond to simulated computer emotion and the potential influence it has on user perceptions and attitudes. Do users respond to simulated emotion in a similar way to human emotion? Do simulated displays of empathy and sympathy provide similar psychological benefits to those reported in human–human interactions? Or are our responses to simulated emotion not particularly strong and of little importance in agent–user interactions?

A number of recent studies have started to address these questions and initial findings have suggested that we respond to simulated emotion in a similar way to human emotion (e.g. Brave et al. (2005)). However, there has been very little research in this space and it remains unclear how we respond to different types of emotional displays. This paper will explore these issues in further detail – we start with an overview of research related to emotional expressions in helping relationships and highlight how a helper's affective displays can influence client perceptions. We then introduce a number of studies that have examined the potential of embodied agents to help people change behaviour and highlight a number of weaknesses and limitations. Following this, studies that have explicitly examined the impact of simulated emotion on user attitudes and behaviour are detailed and discussed. An experiment we conducted to examine the influence of simulated emotion within a nutritional setting is then described, along with discussion of the main findings. We conclude with a discussion of the main limitations of the research and a number of suggestions for future work in this space.

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2. Related work

2.1. Emotional expression in helping relationships

It is important to initially clarify that through the term "emotional expressions" we are primarily referring to the emotions that people outwardly *display* and not necessarily the emotions they are *feeling* or experiencing. Two of the main ways in which we express emotion are through facial expressions (Ekman, 2004) and speech (Murray and Arnott, 1993). Emotion is also displayed through a number of other more subtle cues such as eye contact, posture, gait, and head and body movements (Givens, 2002). A number of these cues are often displayed when expressing empathy (defined by the Compact Oxford English Dictionary as the ability to understand and share the feelings of another) which is frequently cited in the literature as being of the primary elements in building a strong working alliance. Hunt and Hillsdon (1996) discuss the qualities needed for practitioners to help people change eating and exercise behaviour effectively and place a particular emphasis on the expression of empathy. They suggest that empathy involves being non-judgemental (not judging or condoning clients), non-defensive (not taking remarks personally and making inappropriate defensive responses), and actively listening to clients and reflecting accurately. Active listening typically involves adopting an appropriate seating position, maintaining good eye contact, nodding, mirroring a client's facial expressions, and making agreeable verbal responses that provide minimal interruption (e.g. "I see" or "go on"). The words used when expressing empathy are also important – for instance, Coulehan et al. (2001) highlight that reflecting understanding and empathy to clients involves accurately identifying factual content that clients have stated as well as the nature and intensity of their feelings (e.g. "So, if I'm hearing you right, what you really enjoy is going out at night with your friends and having a few drinks" or "That must have been a pretty painful experience for you, you sound like it was very sad"). The timing and context of empathic statements are also crucial – appearing empathetic at inappropriate times can have a negative impact on the working alliance and can be difficult to rectify.

In their review of therapist characteristics that positively influence the working alliance, Ackerman and Hilsenroth (2003) found that trustworthiness, experience, confidence, interest, and openness are essential therapist characteristics that are required in building a strong and effective alliance. Like Hunt and Hillsdon (1996), they suggest that empathy is also an essential component of developing the therapeutic alliance and found that the key elements of empathy include affirming, helping, warmth, friendliness, and understanding. Highlen and Hill (1984) detail how client and helper nonverbal behaviour can be used to communicate emotion, highlight changes in relationships, regulate conversation (e.g. turn taking), provide clues about hidden feelings, highlight an individual's perception of themselves, and to add extra meaning and emphasis to verbal communications. Ambady et al. (2002) found that physical therapists who displayed facial expressiveness through smiling, nodding, and furrowed brows, were perceived by elderly patients as more warm, caring, concerned, and empathetic than therapists that exhibited other combinations of facial expressivity (e.g. not smiling and looking away). In a study conducted by Grace et al. (1995), it was found that counsellor trainees who received nonverbal skills training (with an emphasis on gaining information about a client's emotional state) were given higher ratings for a measure of the working alliance when compared with trainees who did not have this training. Hill et al. (1981) reported that helpers were perceived more positively by clients when they were able to accurately communicate their feelings to clients (through congruent verbal and nonverbal cues). LaCrosse (1975) found that subjects rated counsellors that exhibited affirming nonverbal behaviour (smiles, positive head nods, 80% eye contact, direct shoulder orientation and a 20° forward body lean) as significantly more attractive and persuasive than counsellors that did not exhibit these behaviours.

Analysis of the emotional expressions of health professionals whilst helping clients has provided an insight into the typical emotions they express during a session with a client. For example, Bickmore (2003) analysed the nonverbal behaviour of a fitness trainer and found that three emotions were regularly expressed – a neutral face (during information exchanges), a concerned face (when expressing empathy), and a happy/smiling face (when greeting and saying goodbye to the client, when conversing in social dialogue (e.g. talking about the weather), and humorous exchanges). Similarly, Grolleman et al. (2006) examined the facial expressions of a human smoking cessation coach and found that the most frequent affective displays were serious/empathic, amused, neutral, and joyful.

It is clear, therefore, that the emotional expressions of a therapist can have a strong influence on a client's perceptions of the therapist – this in turn can influence the working alliance, which is closely correlated with therapeutic outcome. It is therefore essential that therapists can effectively express empathy and other relevant emotions in an appropriate way. However, it is unclear whether or not this also applies to interactions with embodied agents.

2.2. Effects of simulated emotion

A number of recent studies have examined the potential for embodied agents to assist people with changing behaviour such as exercise (Bickmore and Picard, 2005; IJsselsteijn et al., 2006; Eyck et al., 2006; Nguyen et al., 2007), dietary habits (De Rosis et al., 2006), smoking (Grolleman et al., 2006), and other general health behaviours (Bickmore et al., 2007b, 2007a; Bickmore and Schulman, 2007; Silverman et al., 2001). However, none of these studies have explicitly focused on the importance and influence of simulated emotional expressions on user attitudes and behaviour.

In general, very few studies have directly examined how users respond to simulated displays of emotion (Beale and Creed, 2009) – whilst there have been a number of research studies over the last decade that have involved the use of an affective embodied agent, the effects of simulated emotion are often not the primary focus of the research (e.g. Lester et al., 1999; Van Mulken et al., 1998; Cassell and Thorisson, 1999; Bickmore and Picard, 2005). For example, Bickmore and Picard (2005) compared an embodied agent that was emotionally expressive with one that was less expressive. However, the main focus of this study was not on the effects of the simulated emotion – it was on how a wide range of relational strategies influenced user perceptions and behaviour. This makes it difficult to determine the precise impact that simulated emotion has on users. Despite this, a number of recent studies have explicitly focused on user responses to simulated emotion and have suggested that we respond to simulated emotion in a similar way to human emotion. For example, Brave et al. (2005) found that subjects perceived an embodied blackjack player that was empathetic toward them as more likeable, trustworthy, supportive and caring than an agent that was not empathetic toward them. Maldonado and Nass (2007) found that subjects perceived an emotionally expressive co-learning agent as more intelligent and trustworthy than an unemotional co-learning agent. Subjects that interacted with the emotional agent also felt significantly more supported than subjects who interacted with the unemotional version.

Fabri et al. (2005) investigated the influence of simulated emotion on users whilst they participated in a moon survival scenario. Subjects interacted with others through the use of a "virtual messenger" and were represented by either an emotionally expressive or unemotional avatar. Results found that participants felt more involved in the task when they interacted with the emotional avatar, as opposed to the unemotional one. However, Fabri reported that subjects enjoyed the interaction with the unemotional avatar more than with the emotional one. Prendinger et al. (2003) examined the influence of simulated embodied agent empathy by measuring subjects' galvanic skin response whilst playing a mathematical game. Results from this study found that empathic expressions during times of frustration (e.g. when a short delay during the game was experienced) helped reduce galvanic skin response in subjects – however, the empathic expressions had no influence on how frustrated subjects felt whilst playing the game.

2.3. Limitations of current research

Whilst the few recent studies discussed previously have examined the effects of simulated emotion on user perceptions, we still have a limited understanding of how users respond to simulated emotion. For instance, as we have seen, two of the primary ways in which we express emotions are through facial expressions and speech – yet our responses to the combination of these two modalities for expressing emotion has not been fully tested. Brave et al. (2005) and Maldonado and Nass (2007) both used static facial expressions with textual content to express emotion, while Fabri et al. (2005) used an animated agent without any speech. Prendinger's agent expressed emotion through an animated agent, along with a synthetic voice, but this creates a mismatch in the emotional expression since the voice lacks appropriate expression. The same also applies with Bickmore and Picard's (2005) embodied agent – emotional facial expressions are combined with monotone synthetic voices. This is important, as earlier research has shown that mismatching emotional expressions along visual and audio cues has a negative impact on user perceptions (Creed and Beale, 2008).

Another issue is that we have little understanding of how simulated emotion influences perceptions in agent–user helping relationships – Section 2.1 highlighted the strong influence that emotional expression can have on client perceptions of a helper, and in turn the working alliance, but does the same apply in agent–user interactions? Bickmore and Picard's (2005) research suggests that it does as a relational version of their agent (which expressed emotion) was respected, liked and trusted more than another version of the agent that did not express emotion. However, emotional expression was not the main focus of this study and was one of many agent characteristics that were manipulated to examine the potential for agents to build and maintain long-term relationships with users. It is therefore problematic to directly attribute the reported effects to the manipulation of emotional expression. As a result, it remains unclear how we respond to agent emotion in a helping domain – do we expect agents to express emotion naturally like a human or does simulation of emotional expression appear false and fake, and result in negative user responses? After all, we know, intellectually, that the agent is computer generated and hence incapable of really experiencing emotion, and so we may distrust its presentation of a faked response.

Another limitation with many of the emotion simulation studies conducted to date is that emotional expressions are not, as Hook (2004) suggests, checked and validated before conducting primary experiments. Researchers, therefore, cannot be sure that the emotions their agent is expressing are being perceived as they expect. We have experienced this ourselves from previous research that we have conducted – for instance, when testing whether users perceived an agent's emotional expression of happiness as expected (expressed through an open smile with teeth displayed, raised eye-brows, and appropriate vocal characteristics), we found that many users thought the agent was displaying a fake smile. This was mainly because they put a lot of emphasis on the eyes when perceiving the emotional expression, and as we did not animate the orbicularis oculi muscle near the eyes (a muscle that is known to be activated in genuine smiles, but not in social smiles (Ekman et al., 1990)), subjects perceived the emotional expression as fake. It is therefore essential that researchers test emotional displays before running primary experiments, but this vital step is often missed and consequently lowers experimental validity.

3. Experimental system

To address the limitations of emotion simulation research highlighted in Section 2, we built an embodied agent to investigate these issues further.

3.1. Agent design

We initially had to decide upon the domain and context within which to create the interaction with an affective embodied agent. We decided to focus on a nutritional domain for four reasons: (1) no study has yet investigated user perceptions of simulated emotion within a nutritional setting, (2) changing of dietary habits has a number of well-defined short interaction techniques, (3) sample dialogue between nutritional coaches and clients is available in related literature, and (4) discussion and improvement of poor dietary habits will be of potential benefit to subjects. After deciding upon the domain of the study, we also had to give thorough consideration to the design of the embodied agent – for instance, the physical appearance of the agent (gender, age and attractiveness), the types of emotions that it would express, how these emotions would be expressed (e.g. whether through facial expressions, textual content, synthetic/recorded speech, etc.), how the agent would interact with subjects and vice versa (e.g. natural language processing, Wizard of Oz approach, pre-scripted responses), and what it would actually say when interacting with subjects.

With regard to the physical appearance of the agent, we initially decided to create an attractive female aged between mid-late twenties. There were a variety of motivations behind this – one reason is that a number of research studies have suggested that therapy is often more effective when the therapist is female (as opposed to gender-matched clients and helpers) and of a similar age to clients (Bickmore, 2003). Therefore, as this study was primarily intended for undergraduate and graduate students at the university (aged approximately between 18 and 24), we decided to make the agent look around mid-late twenties. Another motivation was related to the halo effect where many positive attributes are often associated with attractive people – for example, research has shown that they are often perceived as more likeable, persuasive, dominant, intelligent and sensitive than less attractive people (Cialdini, 2003).

We also had to consider how to present the agent to users – that is, would it be better to display a full body, the top-half of the body (e.g. chest, shoulders, and head), or just the head. Also, should the agent be animated or static, and how should emotional expressions be displayed to users? We decided to use just an animated head (with no other bodily parts) along with a recorded female voice. One of the primary reasons for doing this was related to the difficulty in creating credible and believable emotional expressions – for instance, if the whole body had been displayed, this would have greatly increased the complexity in creating realistic emotional

expressions as elements such as arm and leg positions would have to be positioned appropriately and animated smoothly. Also, elements such as posture and gait could have influenced subjects' perceptions of the emotional expressions. In addition, producing a whole or part-body representation would have reduced the relative space available for the head, and so make the subtleties of changes in facial expression much harder to perceive.

It is important to note that not including other bodily parts did not mean we could not appropriately convey emotion to subjects – as has already been discussed, facial expressions and speech are two of the primary ways in which we express and perceive emotion, and a number of studies with embodied agents have confirmed that human users can correctly recognise and distinguish between different embodied agent emotional expressions when using just a head (e.g. Bartneck, 2001). Therefore, by using only a head, we were still able to adequately express emotions while at the same time were able to reduce the number of variables (e.g. poorly animated gestures) that could potentially influence the perception and credibility of the expressed emotions. Whilst non-verbal behaviours can also be used for purposes other than conveying emotion (e.g. to signal turn taking) we focused predominantly on using the head and facial expressions for the display of emotion given this was the primary focus of the research.

The way in which the user could interact with the agent was another important issue that required consideration. There were a number of options – for example, the agent could have acted like a chatbot and attempted to respond to natural language input from users via typed text or speech input. A Wizard of Oz approach could also have been used in which the user would actually interact with another person through the guise of an embodied agent. However, the primary issue with these approaches was the potential variability between subjects' interactions with the agent. While natural language processing enables computers to interact with users and have conversations with them, this technology has not fully matured, and computers are still unable to interact naturally with users. While a Wizard of Oz approach could potentially resolve some of these issues and result in more natural interactions, it would have still likely resulted in sessions with the agent that were sufficiently different between subjects to have an influence on perceptions of the agent, owing to the experimenter's variability in responses, whether in content or in emotional tone. Also, using such an approach removes many of the advantages of conducting such experiments online (e.g. removal of experimenter bias, automation of experimenter tasks, enabling subjects to complete the experiment in their own time, etc.). Therefore, we decided to use a similar approach to Bickmore (2003) where participants were provided with a number of pre-scripted responses that they could choose from in order to respond to an agent utterance. All agent utterances were also pre-scripted – such an approach gave us a degree of control over the interaction and enabled us to ensure that all subjects had interactions with the agent that were relatively similar.

These design decisions meant that we were able to control the range of dialogue from both the user and the agent, and the domain of the experiment. The variable parameter in the interaction is therefore the emotional expressiveness of the agent – for simplicity, we used two cases. The first is an emotionally neutral expressiveness; the second is an emotional one. For both these cases, the dialogue used by the agent and the choices offered to the user are the same, but are presented differently. The agent was animated to show facial expressions to convey emotion, and the audio used also contained the appropriate emotion. In the neutral case, the responses of the agent were always neutral, regardless of the response chosen by the user: in the emotional situation, the emotion conveyed by the agent was manipulated to be appropriate to the responses chosen by the user.

Fig. 1. Rachael.

The agent was primarily developed through the use of two applications Poser 5 (Poser, 2012) and Mimic 2 (DAZ-Productions, 2012). Poser was used to create the appearance of the agent, while Mimic was used to synchronise recorded utterances with the lips of the agent. We decided to name the agent "Rachael" (Fig. 1).

3.2. Dialogue design

When designing and writing the interaction dialogue, we decided to focus on the context of a typical "first session" with a health advisor. Also, to help guide the writing of the dialogue, we decided to make use of the Transtheoretical Model (TTM) – a behaviour change model that human health professionals often utilise when attempting to help people change behaviour (Prochaska et al., 1994). The model is based on the idea that behaviour change involves movement through a number of different stages – these stages include pre-contemplation (when people have no intention of changing their behaviour), contemplation (when people intend to change within the next 6 months), preparation (when individuals intend to take action within the next month), action (when people have done something to change their behaviour within the past 6 months) and maintenance (when people have maintained the desired change for at least 6 months). The stage of change that an individual is in influences the interventions and strategies that helpers should use to help clients move forward to the next stage of change. For the purposes of this experiment, we decided to focus on the contemplation stage of change to help guide the writing of the dialogue, as this is a stage that many individuals are in when they first visit a health professional.

The structure of the dialogue was therefore based on the components that Hunt and Hillsdon (1996) identified as being appropriate in a first meeting between a health professional and client, along with a number of interventions that they highlight as being essential to helping contemplators build confidence for change. The dialogue was adapted from a number of different sources including Bickmore (2003) and Hunt and Hillsdon (1996) – users were provided with a range of positive, neutral, and negative responses to choose from to enable them to respond to agent utterances appropriately. The following subsections highlight the main sections of the dialogue, along with example interactions between Rachael and subjects. In the dialogue fragments below, R refers to the agent, Rachael, and U to the User. Rachael speaks her utterances, whilst the User is able to choose from a predetermined set of possible responses to each of Rachael's questions or statements.

3.2.1. Introduction and rapport building

Here is a sample interaction that illustrates how the agent introduced itself and attempted to initially build rapport through discussing what the subject does for a living:

R: ... My name is Rachael, it's good to meet you.
U: Hi Rachael, nice to meet you.
R: Are you a student at Birmingham?
U: No.
R: What do you do?
U: I work at another university.
R: Oh right, which faculty?
U: Computer Science **[input via a text box]**
R: That's good ...

3.2.2. Clarification of agent and subject role

Another important step in a first meeting is to clarify both the role of the helper and client, as well as what is expected of both:

R: So, moving on, do you know the exact purpose of this interaction
U: I think so
R: Well, just to clarify, I'm a nutritional advisor and my job is to help you improve your diet. I'll be working with you to set achievable goals that you are confident you can meet. I'll also be giving you a number of useful tips about how you can eat more healthily
R: How do you feel about interacting with me?
U: It's okay.
R: That's good to hear - I should explain that it's not my job to change you. I hope that I can help you think about your present diet and consider what, if anything, you'd like to do about it. However, if there is any changing, it'll be you that does it. I'll be giving you information and some advice, but what you do with it after this session is up to you

3.2.3. Enquire about subject eating behaviour

Following the clarification of roles, the agent then enquired about participants' past dietary habits:

R: So let's start by talking about how your diet has changed over recent years, if at all. Have you tried to improve your diet in the past?
U: Yes
R: And in what particular ways did you try to change it?
U: I tried to stop eating unhealthy amounts of fatty and sugary foods
R: How did you find that?
U: A nightmare – I just found it impossible to meet my goals

3.2.4. Enquire about current diet

After asking the subject about their past dietary habits, the agent then discussed subjects' current eating habits. These questions were based on a self-administered questionnaire developed by the Health Education Authority (Hunt and Hillsdon, 1996) – this questionnaire contains nineteen questions, and subjects were able to provide their responses through the use of textboxes, checkboxes, and radio buttons. Below is an example of some of the questions asked:

R: I'd now like to talk a bit about your current diet. I have around 20 questions to ask so please bear with me. Who does most of the food shopping in your home?
U: I do **[input via checkbox]**
R: And who does most of the cooking?
U: I do **[input via checkbox]**
R: What cooking and storage facilities do you have?
U: Oven, Microwave, Freezer, Fridge **[all input via checkbox]**

3.2.5. Pros and cons of current diet/pros and cons of changing diet

The agent then discussed the pros and cons of the participant's current dietary habits, and the pros and cons of changing those habits. The following sample illustrates how the agent did this:

3.2.6. Pros and cons of current diet

R: ... Just thinking about what you currently consume then, which of the following foods do you like most
U: Greasy high fat foods (e.g. burgers, fried chips, kebabs, etc.)
R: What is it you like about this particular type of food?
U: I enjoy the taste
R: And what don't you like about it?
U: It's not helping my blood pressure and cholesterol levels

3.2.7. Pros and cons of changing diet

R: Let's assume that you did improve your diet. How might you be better off?
U: I'd likely lose some weight
R: And you'd like that?
U: Yes
...
R: What concerns you about improving your diet?
U: That I might get strong cravings for certain foods
R: That's understandable – it's quite normal to have a number of concerns when trying to have a healthier diet

3.2.8. Options for making changes to diet and practical tips

Subjects were then provided with information from the agent about what makes up a healthy diet and how they can go about improving it. In particular, the agent gave an overview of the Balance of Good Health which is a pictorial food guide showing the proportions and types of food that need to be consumed to have a healthy and balanced diet (British Nutrition Foundation, 2012). Following this, the agent provided subjects with a number of practical tips about how they could go about making healthy changes to their diet.

3.2.9. Getting a commitment and terminating the session effectively

At the end of the interaction, the agent attempted to get a commitment from subjects about when they intended to improve their diet, and then terminated the interaction appropriately.

R: So, when do you think you will be able to start making the improvements to your diet
U: Tomorrow
R: Excellent, I think we've made good progress today
U: Yes, I agree
R: Well, I think that just about sums everything up. You may find it useful now to read through the educational pages that will appear on your screen after this session is complete. There will be lots of useful information about how you can eat more healthily including tips, healthy meal suggestions and lots of other resources. Feel free to spend as long as you wish looking through the material ...

3.3. Emotional expressions

Another important consideration was with regard to the emotional expressions of the agent – in particular, which emotions should it express, how should it communicate them, and when should it do so? Based on Bickmore (2003) and Grolleman et al.'s (2006) analysis of the typical emotions expressed by health professionals, we decided to focus primarily on the emotional expressions of happiness, warmth, and concern (empathy), along with neutral displays of emotion. We made use of Ekman's (2004) work on facial expressions and Murray and Arnott's (1993) work on the characteristics of vocal emotions when building the emotional expressions (see Fig. 2 for all facial expressions). For the happy facial expression, the agent's mouth is open with teeth displayed, the lip corners are raised to produce a smile, and the eyebrows are raised. The warm facial expression is similar and involves manipulation of the same parts of the face, with less emphasis. For the neutral face, we did not manipulate any elements of the face, while for the concerned facial expression, the eyebrows were lowered, the eyes were closed a little, and the corners of the lips were lowered. With regard to speech, the speech rate, pitch average and pitch range for the happy voice were faster, higher and wider than the other emotional voices. The warm voice was similar to the happy one, but not quite as extreme. The neutral voice was kept as consistent as possible, while the speech rate, pitch average and pitch range for the concerned voice were slower, lower, and narrower than all of the other voices. All of these emotional expressions were tested in a previous study to ensure that subjects perceived them as expected (Creed and Beale, 2008).

The agent expressed different emotions depending on the context of the interaction – for example, inline with Bickmore's (2003) findings related to emotional expression in helping relationships, Rachael expressed happy and warm emotions at the start and end of the interaction, and during social dialogue. Neutral emotions were expressed during information exchanges, with concerned emotional displays being utilised when the agent was empathetic toward the user. Once the agent had completed an utterance and was waiting for the user to respond, the agent's head was animated to move slightly and to blink – this was to give the impression to the user that the agent was still there (i.e. actively involved in the conversation) and awaiting a response. We ensured that all transitions to different emotional states were smooth – for example, if the agent had a warm facial expression in one utterance, and required a neutral one in the next utterance, the facial features did not jump straight to the new emotional expression. Instead, there was a smooth animated transition where the facial features gradually moved from warmth to a more neutral expression. Two different versions of the agent were developed – an emotional and unemotional one. The emotional agent displayed the full range of affective responses described above, while the unemotional agent only utilised the neutral facial expression and neutral voice. The unemotional agent remained indifferent and neutral throughout the interaction and at no time attempted to display any emotion to users, though the face was animated for the lip synchronisation, not simply static.

Fig. 2. Static facial expressions of agent (clockwise from top-left: happy, warm, neutral, concern).

4. Experiment

4.1. Hypotheses

The following hypotheses were formulated:

H1. Subjects will rate an emotional agent as more likeable, trustworthy, and caring than an unemotional agent.

H2. Subjects that interact with an emotional agent will feel more positive and supported than subjects who interact with an unemotional agent.

H3. Subjects that interact with an emotional agent will be more motivated to utilise the educational resources provided in the system than subjects who interact with an unemotional agent.

4.2. Procedure

The experiment had a between-subjects design with two different conditions – Emotion and No-Emotion. Fifty subjects (20 male, 29 female, and 1 undeclared) completed the experiment and were randomly assigned to one of the conditions (i.e. 25 subjects in each condition). Subjects were recruited both from advertisements made at the University of Birmingham and on the British HCI Group's Usability News website. From the advertisements, subjects were directed to a webpage that contained a number of screening questions. In order to complete the experiment, subjects had to be aged over eighteen, have access to the minimum resources to run the experiment (Internet Explorer v6.0 or above, Flash Player version 8 or above, a broadband Internet connection, sound card and speakers or headphones, and approximately 25 megabytes of free hard-disk space), and had to not currently be following a diet plan recommended by a doctor, or to have any medical history of eating disorders. Subjects that met the criteria were then shown a consent form and asked whether they wanted to continue. If subjects chose to continue, they were then given detailed instructions about the experiment and their interaction with Rachael. After reading the information about the experiment, subjects then had the interaction with Rachael which was about ten minutes in length. After Rachael completed an utterance, subjects then had the opportunity to respond using one of the pre-scripted responses provided (Fig. 3). Once they had completed the interaction, participants were informed that they could view educational resources related to having a healthy lifestyle and diet for as long as they desired. This material included around one hundred articles on health, diet, and exercise (taken from the BBC Website with permission), and a number of healthy recipes. Once subjects had finished looking at the material, they could click a button to take them to the questionnaires. After completing the questionnaires, they were informed that they had completed the experiment and that they could close the browser window.

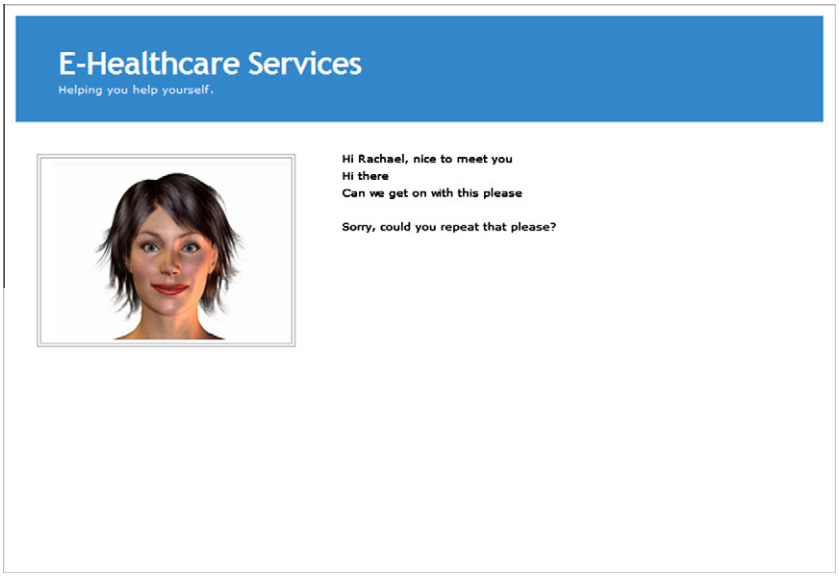

Fig. 3. Screenshot of experimental system (in this example, Rachael has just greeted the user and is waiting for the user to Click on one of the responses provided).

4.3. Measures

The primary measures from this study were taken from Brave et al. (2005) and were a mixture of ten point semantic differentials and single ten point Likert scales. In addition to measuring the main items of caring, likeability, and trustworthiness related to hypothesis H2, we also decided to include Brave et al.'s measure for perceived intelligence, to see if simulated emotion influenced this in any way. The following items were used to measure subjects' perceptions of the agent:

- **Caring** included five items: compassionate–not compassionate, unselfish–selfish, friendly–unfriendly, cooperative–competitive, and the single Likert–scale item, warm.
- **Likeability** included four items: likeable–unlikeable, pleasant–unpleasant, appealing–unappealing, and not irritating–irritating.
- **Trustworthiness** included four items: trustworthy–untrustworthy, honest–dishonest, reliable–unreliable, and sincere–insincere.
- **Intelligence** included three items: intelligent–unintelligent, smart–dumb, and capable–incapable.

We should note here that by "intelligence" we are referring to the more traditional "intelligence quotient" interpretation as opposed to more recent work on emotional intelligence by Goleman (2004). The scales were also used to measure subjects' experience of using the system – in particular, how positive and supported they felt when interacting with the agent:

- **Felt positive** included three items: positive–negative, happy–sad, and pleasant–unpleasant.
- **Felt supported** included five items: supported–unsupported, attended to–not attended to, appreciated–unappreciated, praised–criticized, and not alone–alone.

A ten-point semantic-differential scale was also included to assess how emotional subjects perceived the agent to be (emotional–unemotional). At the end of the experiment, subjects were asked to (optionally) answer eight open-ended questions that focused on things that annoyed them about the agent, things they liked about the agent, whether the agent was better or worse than interacting with just a website, and their general thoughts regarding the system. The amount of time that participants spent viewing the educational resources and the number of articles and recipes they viewed were also recorded as measures of engagement and motivation. We decided to use these two items as measures of motivation and engagement as we felt that if subjects enjoyed the interaction more with the emotional agent than the unemotional agent, this might influence their motivation and willingness to interact with the system, and to learn more about having a healthy lifestyle. On the other hand, we felt that if subjects did not enjoy the interaction with the unemotional agent, they would be less likely to want to continue using the system and would want to proceed to the questionnaires more quickly.

4.4. Manipulation check

There was a significant main effect for emotion with respect to subjects' perception of how emotional the agent was – $F(1,48) = 13.88$, $p = 0.001$) (Fig. 4). The emotional agent was perceived as more emotional than the unemotional agent.

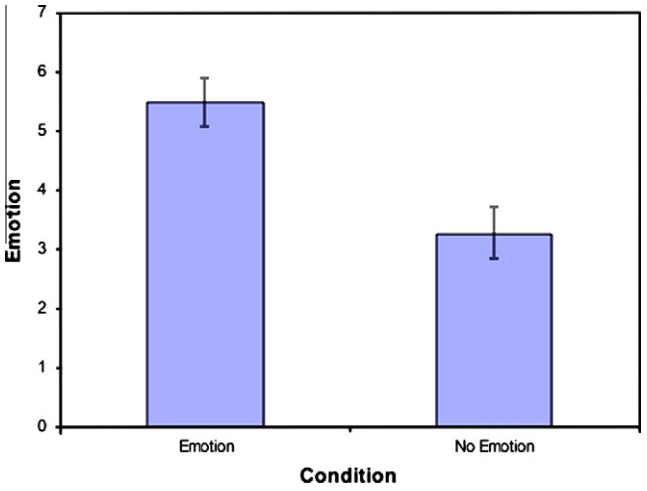

Fig. 4. Perceived emotion of the agent.

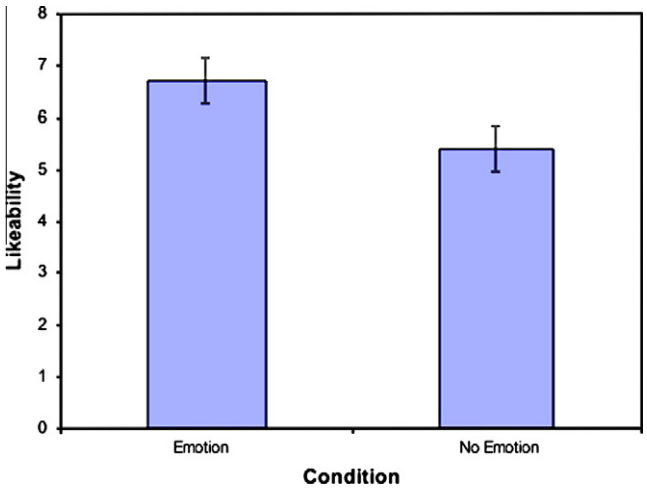

Fig. 5. Perceived likeability of the agent.

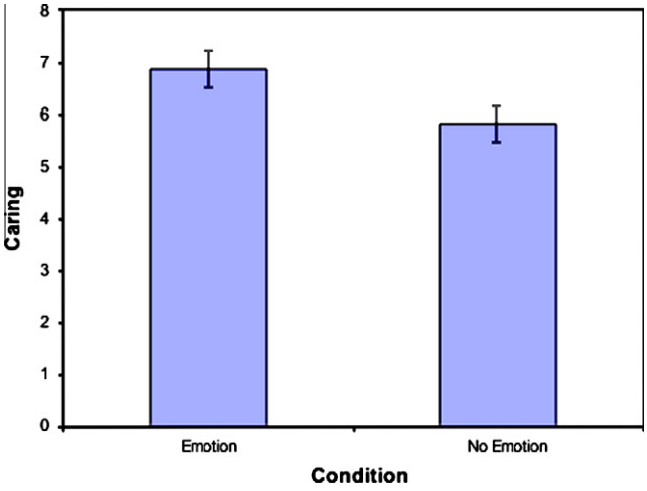

Fig. 6. Perceived caring of the agent.

4.5. Likeability

There was a significant main effect for emotion with respect to likeability of the agent, $F(1,48) = 4.44$, $p < 0.05$, such that the emotional agent was perceived as more likeable than the unemotional agent (Fig. 5).

4.6. Caring

There was a significant main effect for emotion with respect to caring, $F(1,48) = 4.48$, $p < 0.05$, such that the emotional agent was perceived as more caring than the unemotional agent (Fig. 6).

4.7. Trustworthiness

There were no significant main effects with regard to trustworthiness of the agent ($F(1,48) = 0.58$, $p = 0.45$).

4.8. Intelligence

There were no significant main effects with regard to perceived intelligence of the agent ($F(1,48) = 1.20$, $p = 0.279$).

4.9. Felt positive and felt supported

There was no significant main effect for emotion with respect to feeling positive ($F(1,48) = 3.53$, $p = 0.066$) or in how supported subjects felt whilst interacting with the agent ($F(1,48) = 1.41$, $p = 0.242$).

4.10. Time viewing educational resources and number of educational pages viewed

There were no significant main effects with regard to the time that subjects spent viewing the educational material ($F(1,48) = 1.44$, $p = 0.236$). There were also no significant main effects with regard to number of educational pages and recipes that subjects viewed ($F(1,48) = 2.48$, $p = 0.122$).

4.11. Subject feedback

Question 1 – Was there anything about the character that annoyed you?

In response to this question, seventeen of the 25 subjects in the No-Emotion condition made a comment related to the "monotonous" tone of the agent's voice:

"... irritating bland voice tone... sounded patronising." [No-Emotion]

In contrast, only two subjects in the Emotion condition made reference to the voice:

"[I didn't like] ... the accent and the fake perkiness..." [Emotion]

Another issue that was raised from the comments in the Emotion condition was that of the lip synchronisation – four subjects made reference to this and suggested that it was something that annoyed them about the character. One subject highlighted another annoyance related to the insincerity of the agent:

"The insincerity of her 'I can understand that' phrase. It was OK once but then needed the back up of why she can understand it. It was much better when she said 'I can understand that, it can be hard making these changes, I think a lot of people find that' or something like that." [Emotion]

Question 2 – Was there anything that you liked about the character?

Comments from the Emotion condition tended to focus on expressiveness of the face and speech as something they liked, in addition to the "friendliness" of the agent:

"That she looked 'real' - that she was obviously graphically taken from a real person with real face expressions [the agent was not developed in this way] - that she smiled and had some emotional expressions." [Emotion]

With regard to the No-Emotion condition, subjects tended to focus more on the visual characteristics of the agent when answering this question:

"...She was pretty, and her haircut and eyes seemed realistic..." [No-Emotion]

Two subjects also made reference to liking the local accent of the voice – one subject also liked the fact that the agent was female and of a similar age. Also, in complete contrast to the majority of comments from the previous question, one subject appeared to like the neutral voice:

"... pleasant sounding voice; could describe as [having a] reassuring quality..." [No-Emotion]

Question 3 – Was interacting with the character better or worse than interacting with just a website?

Eleven subjects from the Emotion condition directly stated that they felt the interaction with the agent was better than using a website – some of the reasons included the fact that it was "...more entertaining", "... a little more interesting and friendly", and because it "... simulated some degree of human contact." Four subjects felt it was worse, while others were unsure:

"I quite liked it in a way that she was there, I guess I didn't feel as alone, but still her restrictions graphically would probably annoy me - and I think more than that the fact that she doesn't respond like a human in that you know her responses are programmed. If she could respond spontaneously then I could build a rapport with her and would think of her as a supportive friend." [Emotion]

As with the Emotion condition, eleven subjects in the No-Emotion condition directly stated that they felt that interacting with the character was better. Nine subjects, however, felt that it was worse, while others were not so sure:

"... I think answering the questions by reading them on a website would have been quicker and I would have felt taken more seriously." [No-Emotion]

Question 4 – Would you choose to interact with the character again?

Eleven subjects in the Emotion condition indicated that they would like to interact with the agent again in the future, with only two directly saying that they would prefer not to. Other subjects were unsure:

"...If I felt she wouldn't just give me programmed responses then yes. I like the idea of having a supportive friend who could motivate and coach me..." [Emotion]

In the No-Emotion condition, many more subjects directly indicated that they would prefer not to interact with the agent again – twelve in total (compared with only two in the Emotion condition). Eight subjects, however, still stated they would like to interact with the agent in future, while others were indifferent or unsure.

Question 5 – Did you find any of the material/articles provided interesting/useful?

There was a mixed response between conditions in relation to this question – some found the material presented to be useful, while others felt it was little basic and may be of more use to younger users:

"I work in health sciences so knew most of it. Suggested use for this would be at schools, where I think the level would be ideal and could see a real benefit." [No-Emotion]

"... not specific enough to the answered questions - very basic information" [No-Emotion]

Question 6 – Did you have any problems when using the system?

There were a variety of responses to this question that highlighted a number of minor issues with the system that could be improved for future experiments – in particular, subjects could not go back to previous utterances to change their answer if they accidentally selected the wrong response. Also, one subject wanted an option to skip questions that they felt were not applicable to them. A couple of subjects also wanted more responses to choose from when responding to the agent's utterances.

Question 7 – What did you think of the system in general?

Comments from this question produced a variety of positive and negative responses:

"I'm very impressed. I liked it, however it gets a bit repetitive after a while, might be nice if the character was a bit more intelligent." [Emotion]

"... think it's an improvement to have an avatar present, though more work needs to be done to make it more spontaneous. More work needs to be done on the contents of the site to make it less limited." [Emotion]

"I felt being lectured and didn't like it." [No-Emotion]

Question 8 – Any other comments?

This question provided a wide range of responses from subjects in both conditions:

"I actually think its a good idea, it would be good if you could speak to the person [computer] everyday to say how your going, also enter your weight in once a week, very good idea" [Emotion]

"It might be a good idea to give people a record of their goals after using the system. It can be very easy to walk away from the computer and forget that you agreed that you would use dried fruit rather than sugar on your cereal, for example." [No-Emotion]

"...won't work and anyway this whole idea of endless self-policing is profoundly unethical..." [Emotion]

5. Discussion

The results of this experiment found that simulated displays of emotion influence user perceptions in a number of ways. Hypothesis H1 received strong support as the emotional agent was perceived as significantly more caring and likeable than the unemotional agent. However, this was not the case for perceptions of trust and intelligence – there was no significant difference in how trustworthy or intelligent subjects perceived the emotional and unemotional agents to be. Hypothesis H2 received no support – there was no significant difference between the two conditions with regard to how supported or positive subjects felt. Hypothesis H3 – related to use of the educational materials – also received no support. Comments from subjects regarding the final eight questions provided an interesting insight – for instance, in the No-Emotion condition, the neutral voice generated the most comments – people found it monotonous, boring, and patronising. In contrast, for the Emotion condition, the emotional voice was largely reported as something that participants liked about the agent. Subjects reported liking the visual appearance of the agent in both conditions – however, while subjects' comments in the No-Emotion condition focused predominantly on the visual components of the agent (e.g. "I liked the movement of the eyes"), subjects in the Emotion condition also provided positive comments related to the emotional expressions. They liked the fact that the agent was friendly, warm, and cheerful. However, it should be noted that some people provided different responses – some liked the neutral

voice of the unemotional agent and described it as "pleasant" and has having a "reassuring quality," while others in the Emotion condition did not like the "fake perkiness" or "strong accent".

The emotions expressed by the agent in this experiment tended to be "positive" ones – that is, the emotional agent attempted to consistently be happy, warm, and empathetic at appropriate times. An important question therefore is whether or not positive emotions are always best and whether they should always be incorporated into an agent? Instead, it might be beneficial for agents to express "negative" emotions in an attempt to help motivate people more effectively. For example, if a helping agent were to express emotions of anger, frustration, and disappointment at a user who had not achieved their weekly goals this may actually be more effective than having a "likeable" agent that always attempts to be positive. The effectiveness of negative emotional expressions are very much likely to depend on several factors such as the context of the interaction, the quality of "relationship" between an agent and client, and the personality of the user. This represents an interesting future research area where little work has been conducted to date.

The fact that the voice of the agent produced the majority of negative comments in the No-Emotion condition is interesting – both visual and audio elements of emotional expressions are known to influence perceptions of emotional expression (De Gelder and Vroomen, 2000), however, the voice here appeared to dominate subjects' perception of the agent. In contrast, there were very few comments about the neutral facial expressions – this did not appear to bother people as much as the neutral voice. This is also strange when we think of the "Uncanny Valley" effect (Mori, 1970) – people are often more critical of the appearance of an agent the closer it gets to looking human – however, many provided positive comments about the appearance of the agent. The vocal aspect of the agent may have dominated subjects' perceptions because the voice used was recorded by a human, while the facial expressions were computer generated. Subjects may have had higher expectations of the human voice, and when it did not express emotion naturally (or as they expected), it strongly influenced their perceptions. In contrast, as the visual characteristics of the agent were obviously computer generated, subjects may have had lower expectations of the agent's ability to express emotion, and were therefore not as strongly influenced when the agent did not display natural facial displays.

While a number of subjects stated that they would prefer to use the agent over a website, a relatively high number still stated that they would prefer to use a website only. One of the primary issues cited was the time taken to complete the interaction – the interaction with Rachael lasted approximately ten minutes and it appears that this was too long for many subjects. While a large number of participants stated that they would like to interact with the agent again, there was a large difference between conditions in relation to those who stated that they did not want to interact with the agent again (twelve in the No-Emotion condition, compared with two in the Emotion condition). This would suggest that subjects disliked the unemotional agent substantially more than the emotional agent. It also appeared that many subjects found the content of the interaction and the material presented a little too basic (although there were again contrasting views) – this is obviously influenced by a number of factors such as the users' previous knowledge on nutrition, diet, and exercise.

The research of both Brave et al. (2005) and Maldonado and Nass (2007) suggests that emotional agents would be more trusted than unemotional ones, and thus the fact that no effect was observed, despite the emotional agent being perceived as more likeable and caring than the unemotional one, is a surprising result. Whilst it could be that the experiment here had insufficient power to identify a significant effect, it does at least suggest that the effect is subtler than has previously been assumed. One potential avenue of explanation could simply be that a lack of emotional expression did not necessarily result in lower perceptions of trust. For example, as one subject in the No-Emotion condition commented, the unemotional agent had a "reassuring quality" to it – while other subjects did not make similar comments, it could be that they had a similar perception of the agent and did not rate the unemotional agent down with regard to trust. Also, as trust is something that is often built over time and numerous interactions, it could have been that the meeting with the agent was not of sufficient length to observe an effect. Studies that involve multiple and extended interactions with an embodied agent would help identify if this is the case.

Another factor that may have influenced the results of this study was a comment that several subjects made in relation to the lip synchronisation of the agent. While a large amount of effort was put into synchronising the lips, facial expressions, and speech, people are particularly perceptive at picking up synch issues. For instance, Reeves and Voelker (1993) found that even when lip synchronisation on television set is only very slightly out and people are not consciously aware of it, it can still result in negative perceptions of the people speaking. Therefore, if there were occasions where the lip synch was not perfectly synchronised, subjects may have unconsciously (or consciously) picked up on this, and it might have influenced their perceptions in a negative way. In future studies, the influence of lip synchronisation should be carefully studied before conducting main experiments.

No significant effects were found in relation to the number of educational pages that subjects viewed or the amount of time they spent viewing them. We therefore found no direct evidence to support the idea that the emotional agent would engage and motivate subjects more than the unemotional agent, in terms of the impact of the interaction. However, subjects' motivation to continue with the emotional one was higher, which is somewhat indicative of increased engagement, but more work is needed to identify any relationship between these. We do speculate that, as the length of the interaction was a common complaint, it may have been that once subjects had completed the interaction with the agent, they did not want to devote a further lengthy period of time to reading articles.

6. Future work

Future work needs to focus on running similar experiments over extended periods of time to help understand how we respond to simulated displays of emotion across multiple interactions. Very few long-term studies have been completed to date and we still have a very shallow understanding of how we respond to affective agents over longer periods of interaction. This is an area that we are focusing on with the agent described in this paper – we plan to use the agent to see if it can help people eat more daily portions of fruit and vegetables over a period of 12 weeks. Subjects will be asked to have weekly interactions with the agent that will utilise a number of skills and strategies to assist people with improving their dietary habits.

Another important area to investigate is the effect that displaying more of an agent's body has on user perceptions. The focus of this research was predominantly on expressing emotions and empathy through use of speech and facial expressions and examining user responses. However, in terms of looking more broadly at expressions of empathy during interactions with agents, there are several other non-verbal elements to agent–user interactions that can potentially influence user attitudes and behaviour. These include the appearance of the agent, sitting positions, body movements, eye pointing, mirroring and timing of facial expressions, and the use of pauses. It is important that future research examine

the potential impact that these other elements can have on agent–user interactions.

An additional area that merits investigation is to replicate this experiment in alternative domains to ensure that the effects observed are transferable and not specific to the health domain. We have no reason to suspect that the general results achieved would not also be evidenced in other areas, and other studies seem to suggest this, but detailed, conclusive proof is not available at the current time. A further area to examine is the potential for such agents to manipulate users for questionable purposes – there has been a recent focus on the potential for socially intelligent agents to manipulate and abuse users, and further work is required to understand this potential (Angeli and Carpenter, 2005; Creed and Beale, 2006). If we perceive emotionally expressive agents to be more likeable and caring, can they potentially manipulate people more effectively? Are emotionally expressive agents more effective at eliciting personal information from people than unemotional agents? In this paper we have focused on how agents can influence user behaviour for beneficial purposes, but there is always the potential that this technology could be abused for more questionable goals.

Other interesting areas to focus on would be to run the experiment with non-students and other user groups to see if the same results are obtained. The experiment could also be conducted again using a different range of measures such as the Jefferson Scale of Physician Empathy (Kane et al., 2007), empathy measure (Hogan, 1969), or the Interpersonal Reactivity Index (Davis, 1983) to see if the results are replicated. It would also be interesting to compare how the behaviours of real advisors and clients compare to the current agent–user interaction. This could be used to help understand deeper the subtleties that occur in such interactions and whether they could potentially be incorporated into a new and improved version of the agent.

7. Conclusion

This paper describes the first study to examine the effects of simulated emotion using an embodied agent within a nutritional domain. In particular, it highlights the influence that simulated agent emotion can have on user perceptions with emotionally expressive agents being perceived as more likeable and caring than unemotional agents. The unemotional agent was generally perceived less positively with subjects putting a particular emphasis on the neutral voice as something they strongly disliked. Future work now needs to focus on other types of emotions and in particular how we respond to simulated emotion over time. It is also important to examine whether a likeable agent is actually more effective in gaining compliance – it could be that an agent that is intentionally less likeable and friendly could achieve better results in assisting with behaviour change. These areas represent important future research areas that require detailed investigation.

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