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Creative Technologies for Behaviour Change

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CREATIVE TECHNOLOGIES FOR BEHAVIOUR CHANGE

by

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Copyright Statement

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Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other University award without prior agreement of the Doctoral College Quality Sub-Committee.

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Creative technologies for behaviour change

Joana Galvão Gomes da Silva

ABSTRACT

This thesis presents innovative uses of technology to support motivation, using motivational interviewing (MI) and functional imagery training (FIT) scripts developed specifically for remote delivery. MI scripts aimed to develop discrepancy, evoke solutions and promote self-efficacy. FIT scripts included multi-sensory mental imagery exercises at key points in the MI scripts. Four methods of delivery were developed: a human video-counsellor, a NAO robot programmed with Choregraphe software, a video robot counsellor for comparison with the human video-counsellor, and a life-sized two dimensional 'holographic' projection.

Four empirical studies tested these developments in participants wanting to become more physically active. Study 1 (N=18) and Study 2 (N=20) used qualitative methods to explore the usability and acceptability of MI delivered by a pre-recorded human video counsellor and NAO robot respectively. Analysis of participants' verbal dialogue with the video counsellor in Study 1 showed high levels of change talk, an important ingredient of effective MI. In both studies, participants reported that voicing their goals aloud was helpful but they were somewhat frustrated by the lack of personalised response. Participants positively appraised the non-judgemental aspect of the interview with the robot.

Study 3 tested if virtual FIT would be more acceptable and effective than virtual MI. Ninety-eight participants received FIT or MI delivered by a video robot, and

compared to a wait-list control group. In Study 4, 104 participants were randomized to a monologue version of FIT delivered by a human counsellor projected as a two-dimensional life-size hologram, or on a computer screen, or a wait-list control condition. Neither Study 3 or 4 found any quantitative effect of virtual counselling on physical activity, self-efficacy, or motivation. As in studies 1 and 2, although participants found the technological interaction somewhat impersonal, qualitative responses were largely positive: participants liked the opportunity to voice their goals, reported a motivational boost, and perceived the virtual coaches as non-judgmental.

This research has shown that people perceive benefits from speaking aloud about their goals and problems, and even engaging silently in imagery-based counselling. There is potential to deliver a brief motivational intervention that is fully-automated and acceptable to participants.

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List of Abbreviations

ASD Autism Spectrum Disorder
BIT Behavioural Intervention Technologies
BMI Body Mass Index
CBT Cognitive Behavioural Therapy
CMYK Cyan, Magenta, Yellow, and Black
EI Elaborated Intrusion
EU European Union
FIT Functional Imagery Training
GMS Goal Motivation Scale
HSE Health Survey for England

ICBT	Internet-delivered cognitive behaviour therapy
IPAQ	International Physical Activity Questionnaire
MET	Metabolic Equivalent Task
MI	Motivational Interviewing
MISC	Motivational Interviewing Skill Code
MITI	Motivational Interviewing Treatment Integrity
NICE	National Institute for Health and Clinical Excellence
PA	Physical Activity
PAF	Physical Activity Frequency
PAS	Physical Activity Strength
QUT	Queensland University of Technology
SAR	Social Assistive Robotics
TAFIT	Technology-delivered Functional Imagery Training
TAMI	Technology-delivered Adaptations of Motivational Interviewing
WHO	World Health Organization

Chapter 1: General Introduction

Overview

This project, entitled Creative Technologies for Behaviour Change, was part of the interdisciplinary CogNovo doctoral training in Cognitive Innovation which was dedicated to integrating psychology and neuroscience with arts and technology. The challenge of this PhD project consisted in generating a motivational tool to encourage people to change their behaviour. There are tools to help people plan and monitor their activity, but those tools need the person to be motivated to use them, as well as to engage in the activity itself. We focused on developing an apparatus to prompt motivation. For this reason, we developed virtual health interventions based on psychological theories of motivation and existing counselling techniques with the use of embodied and virtual coaches. We carried out initial testing in the context of encouraging physical activity (PA), using qualitative and quantitative research methods to explore whether these motivational interventions are acceptable and effective when implemented in technology rather than through one-to-one human interaction. We utilized a range of technological devices—video, 2D projection, and robot—as coaches to deliver motivational support that would have the potential to reduce time and cost of standard face-to-face assistance.

Thesis Structure

This thesis comprises eight sections. The first chapter presents the theoretical background that establishes the relevant literature and key ideas for the proposed project. Chapter 2 covers the creative development—conceptual and technical challenges—as the project unfolded. The third and fourth chapters report the initial empirical aspect of this project, one for each of the exclusively qualitative studies run. The first study assessed participants' reactions to a motivational interview delivered by a pre-recorded human video coach. The second study used the same methods to test a face-to-face robotic interviewer. Chapter 5 reflects upon the experience of a secondment at Queensland University of Technology in Australia, an integral part of this doctoral training programme. The secondment took place between the completion of the empirical work reported in Chapter 3 and 4, and informed the development of the work reported in Chapters 6 and 7. Chapter 6 and 7 present the remaining empirical component with two trials—studies 3 and 4—exploring the acceptability and efficacy of virtual coaches. Study 3 utilized a video robot to deliver both motivational interviewing (MI) (Miller, 1983) and functional imagery training (FIT) (Kavanagh et al., 2014) dynamically. Functional imagery training is a new psychological intervention, based on Elaborated Intrusion (Kavanagh, Andrade, & May, 2005), which essentially delivers a motivational interview through the medium of mental imagery. The interviewer guides participants through a series of imagery exercises designed to explore their dilemma, elicit solutions, and strengthen motivation. Having established in studies 2 and 3 that remotely-delivered motivational interview was acceptable and helpful, Study 3 tested the prediction that remotely-delivered functional imagery training would be even more beneficial. This hypothesis is informed by the idea that FIT depends less on the dialogue between the participant and interviewer, which is inevitably compromised by pre-recorded delivery, and trial data showing that FIT is superior to MI for supporting weight loss (Solbrig et al., 2018). Study 3 also tested if a video of a robot coach would retain the benefits of face-to-face interaction with the physical robot with a format better suited to mass remote delivery. Study 4 used a minimal FIT script in which the coach talked the participant through a series of imagery exercises, drawn from functional imagery training, without the two-way dialogue used in the previous studies. The script sought to capture a psychologically active aspect of functional imagery training in a way that was suitable for projection in a continuous recording without edits for 'listening'. It was delivered via a life-size projected human 2D coach. The eighth chapter encompasses the conclusion and insights gathered during the development of this project.

Policy and theoretical background

The aim of this research was to create behaviour change technologies to address increasing healthcare needs. Health organizations consider eHealth to be crucial for covering the basic health needs of the population as well as expanding the service of healthcare systems (World Health Organization, 2012; European Commission, 2012b). We adapted existing theory-driven counselling techniques that have been established in face-to-face interactions—MI and FIT—into technological deliveries by using virtual coaches that could potentially maintain the essence of each motivational method. The following sections explore the current state of eHealth, the diverse technological apparatus that have been employed in healthcare research, and MI and FIT as effective behaviour change techniques in face-to-face interventions and potentially adaptable to virtual delivery. We tested our motivational devices, in the context of encouraging physical activity for ease of recruitment and because increased physical activity brings many health benefits to a predominantly inactive population.

The future of behaviour change

eHealth policies

The major problems in the current state of healthcare are accessibility, quality, and cost (Hill & Powell, 2009). One of the ways to close the gap between demand and healthcare service with a low cost is through the use of technology. The World Health Organization (2012) has elaborated a National eHealth Strategy Toolkit to reflect on the growing impact of eHealth globally and to guide countries on developing their own initiatives as health systems face stringent economic challenges and greater demands for healthcare.

The European Commission (2012) has also released an eHealth Action Plan for 2012-2020 embracing innovative healthcare for the 21st century. This action plan encourages the adoption of eHealth throughout the European Union (EU). As public health expenditure in the EU is increasing due to ageing population and other socio-economic and cultural factors together with pressure on public budgets and decline in the number of health personnel, reforms are needed to ensure the sustainability of the health systems. The European Commission (2012) emphasizes that eHealth is an area with high potential to grow, increasing patients' empowerment and reducing of expenditures.

One of the key aspects of eHealth is not only to improve behaviour but to reach a larger number of people (Vandelanotte et al., 2016). For instance, the use of telemedicine services can improve access to care, reaching patients living in remote areas with shortage of specialised healthcare professionals (European Commission, 2012a). Telemedicine and other types of technologies currently being employed are mostly not intended to replace face-to-face consultations but to complement existing healthcare delivery and increase its efficiency. Technology has the potential to reduce costs, delivering additional assistance to larger numbers of people as for prevention and motivational support.

Behaviour change and physical inactivity

Governmental organizations have been establishing not only plans for incorporating eHealth into the existing system, but also guidance for designing behaviour change interventions. Investing in the population's changes of lifestyle could prevent heavy financial consequences to the health system by reducing the burden of diseases such as type 2 diabetes and cardiovascular disease that are linked to overweight and physical activity (e.g., Helmrich, Ragland, Leung, & Paffenbarger, 1991; Jenum et al., 2006; Ardern & Kuk, 2008).

The World Health Organization (2008) places behavioural risk factors as a leading cause of mortality in the world, mainly in the WHO European Region. In the U.S., the leading cause of death in 2000 were tobacco, poor diet, physical inactivity, and alcohol consumption contributing to escalating care costs with a preventive orientation becoming urgent (Mokdad, Marks, Stroup, & Gerberding, 2004). In the UK, between 1993 and 2012, the percentage of adults with overweight—with a body mass index (BMI) in between 25 and 30—increased from 57.6% to 66.6% among men and from 48.6% to 57.2% among women (HSCIC, 2014). There were 10,957 admissions to NHS hospitals with a primary diagnosis of obesity in 2012-2013. The prediction for 2050, in the UK, is that about 60% of men, 50% of women, and 25% children will be obese—BMI of 30 or more—with £45.5 billion of future cost associated with health problems per year (King & Thomas, 2007). Regarding physical inactivity, approximately 3.2 million people die every year due to the lack of activity (World Health Organization, 2010b). Being physical inactive is one of the leading causes of non-communicable diseases (Hallal et al., 2012), the fourth leading cause of death worldwide (Kohl et al., 2012), and responsible for 6% of deaths globally (World Health Organization, 2010a). In 2012, only 67% of men and 55% of women met the UK guidelines for aerobic physical activity—elaborated by the Chief Medical Office—while 26% of women and 19% of men were considered inactive, based on self-report (HSCIC, 2014). However, the Health Survey for England (HSE) (2008), reported using objective measures through accelerometry that only 6% of men and 4% of women achieved the government's recommendations regarding physical activity. No one policy will fix the problem, it requires a multifaceted response supporting healthy eating and activity habits (King & Thomas, 2007) and eHealth could be part of this response.

Investing in prevention and behaviour change can counterbalance this scenario. The World Health Organization (2010a) recommends that adults perform 150 minutes of moderate-intensity or at least 75 minutes of vigorous-intensity aerobic physical activity during the week plus muscle-strengthening activities at least twice a week. The Global Recommendations on Physical Activity for Health are intended for the following outcomes: cardiorespiratory health, metabolic health, musculoskeletal health, functional health and prevention of falls (World Health Organization, 2010a). Enhancing physical activity levels reduces the risk of cardiovascular disease, metabolic disease, and cancer (Sundberg, 2016). Lee and colleagues (2012) calculate that if inactivity were decreased by 25%, more than 1 million deaths could be avoided every year. There is a linear relationship between the volume of physical activity and health status with the greatest improvement seen when people who are least fit become physically active (Warburton, Nicol, & Bredin, 2006). Even modifying behaviour during elderly years enhances life span (Yates, Djoussé, Kurth, Buring, & Gaziano, 2008).

Helping the population to become more physically active requires countries to develop and implement a combination of policies aiming at informing, motivating, and supporting individuals in their endeavours (World Health Organization, 2010b). The WHO has developed behaviour change strategies to help Member States to incorporate interventions that are feasible, acceptable, equitable, and effective. The National Institute for Health and Clinical Excellence (NICE) developed a series of guidelines for behaviour change to help to change people's attitudes and behaviour (NICE, 2007). According to NICE's guidance on planning and designing an effective intervention, it should be specific about its content, state what is done and to whom, and make the underlying theories clear; objectives that we considered when developing our motivational tools.

There is a need for behaviour change interventions at a population level, but many effective strategies as outlined in NICE guidelines are designed for one to one delivery that would be costly and impractical to deliver on a large scale. Technology can help deliver health interventions cost-effectively but its potential for behaviour change has yet to be fully realised. This doctoral project aimed to produce and test remote psychological interventions delivered through technological devices to motivate physical activity.

eHealth development and current state

Oh and colleagues (2005) found 51 unique definitions in the publications reviewed about the meaning of eHealth. All of the terms mentioned the involvement of health and technology. With the exponential growth of innovative forms of technology, there will always be new mechanization processes to be incorporated to the concept of eHealth, thus the term becomes flexible to embrace future innovation. Technologies formerly developed can progressively become outdated and unimaginable solutions might come to existence in a field that is constantly changing and expanding.

Behavioural Intervention Technologies (BIT) encompass a series of mechanization tools as telephone, videoconferencing, web, mobile, social media, virtual reality, and games (Mohr, Burns, Schueller, Clarke, & Klinkman, 2013). Mohr and colleagues (2013) reviewed the current state of these technology-based behavioural and psychological interventions. Videoconferencing and standard telephone technologies have been generally effective and acceptable to patients maintaining the standard structure of psychotherapy but losing some information in communication between the therapist and patient. Web-based interventions have also shown efficacy for a range of mental health outcomes. However, implementation of other technologies is limited by cost and capability. For example, virtual reality interventions are relatively expensive to programme and natural speech software is still too limited for convincing conversational agents, that is, images of humans who interact with a user (Mohr et al., 2013). We note that this area is advancing rapidly through machine learning, cloud-based language processors such as Siri, Alexa, and Google Natural Language.

The heterogeneous use of technology to translate behavioural and psychological support poses challenges of different levels. Schueller, Muñoz, and Mohr (2013) analyse the strengths and weaknesses of behaviour intervention technologies. According to this team of researchers, the use of technological interventions can transcend time, culture, and even language in a near future but can also face challenges as the quick obsolescence of technology and the lack of collaboration between psychologists and developers. The advancements in technology occur more rapidly than psychological interventions can be tested and the collaboration between psychologists and developers becomes crucial so theory-based intervention should be evaluated and disseminated in an agile form. Academians and industry depend on each other's skill to move eHealth forward (Borrelli & Ritterband, 2015). Baker, Gustafson, & Shah (2014) also express their concerns with the quick pace to which eHealth interventions appear and change, suggesting strategies for increasing timeliness of such technologies, i.e., that the results are useful, relevant and not outdated when they come out. Some of their recommendations include: conducting small studies for quicker results, using efficient designs, studying timeless behavioural and psychological systems for more durable results, anticipating the next big thing to work in future, reducing the costs of care for improved dissemination, and understanding users for more potential engagement. It is not an easy task to develop behaviour change technologies quickly and effectively. Patrick et al.

(2016) propose an iterative process with focus on an 'agile science', in which multiple solutions are tested simultaneously in a quick fashion. We attempted to capture the ever changing state of eHealth when creating our virtual interventions, by designing and evaluating their initial impact in smaller studies with qualitative feedback rather than measuring long term behaviour change.

Transposing counselling techniques to technology faces diverse obstacles. Existing theories may need to be revised to include the constraints and the creativity of technologies (Borrelli & Ritterband, 2015). Yet a gamut of emerging technologies have been recruited to engage people in behaviour change without the usual face-to-face interactions. Omaki et al. (2016) performed a systematic review of technology-based interventions for unintentional injury prevention education and behaviour change that included a range of technologies—software programmes, remotely hosted internet programmes, mobile technology or portable devices, and virtual-reality interventions. All the technologies employed had some positive effect in bringing knowledge or changing behaviour. They detected in their review that there was little information on how these interventions changed behaviour. Oosterveen, Tzelepis, Ashton, & Hutchesson (2017) systematically reviewed eHealth interventions targeting a range of behaviours—smoking, nutrition, alcohol, physical activity, and obesity—for young adults which included the use of websites, emails, text messages, computers, monitoring devices, and mobile apps. Their results suggest that eHealth interventions are more effective than control conditions in the short-term but there is insufficient evidence about the most efficient modality of delivery. Andersson, Cuijpers, Carlbring, Riper, &

Hedman (2014) conducted a meta-analysis on the efficacy of Internet-delivered cognitive behaviour therapy (ICBT) compared to face-to-face CBT. As with Oosterveen's later study, they found that ICBT and face-to-face treatment had equivalent overall effects in short-term but were unable to analyze the long-term effects of treatment due to differences in study designs. Technological tools have been created that seem effective in changing behaviour but, without a clear understanding of their underlying mechanisms, it is hard to identify opportunities for improvement or predict which mode of delivery will be most effective.

Others have been trying to understand the components needed to create helpful health technological support. Webb, Joseph, Yardley, & Michie (2010) detected in their review and meta-analysis that remote interventions with more extensive use of theory and inclusion of more behaviour change techniques had increased effect sizes on health-related behaviours. They also found that the effectiveness of Internet-based interventions was enhanced by the use of additional interactive components as email and text messages. In their overview of the state of evidence for eHealth positive outcomes in physical activity and dietary behaviours, Vandelanotte and colleagues (2016) formulated a series of recommendations, based on the results of the reviewed studies, to improve eHealth tools, including: enhancing interactivity of the technological delivery for higher usage and engagement, examining the effectiveness of specific components in isolation, and increasing the level of detail of the intervention description in study reporting. Kreps and Neuhauser (2013) consider other factors when implementing virtual intervention with the use of artificial intelligence. They suggested that eHealth programs would feel more immediate if they asked for consumer input on health care decision, encouraged consumers to express their own preferences, showed appropriate empathy, and motivated behaviour change.

We took into consideration the above aspects in the challenge of developing and evaluating our motivational tools. We used theory-based counselling techniques and especially aimed at interactivity to motivate behaviour change. Our virtual coaches' interactive design intended to mimic face-to-face motivational sessions. Videoconferencing has been used by therapists with good user satisfaction (Backhaus et al., 2012), spreading its territory, showing potential to reach a greater number of people than delivered face-to-face.

Rochlen and colleagues (2004) describe how professionals have been using the Internet for treating patients by distance in their review about online therapy. Online therapy would substitute or implement face-to-face interactions by a virtual component. Among the benefits of such interactions is convenience and access (Rochlen et al., 2004). Danaher and Seeley (2009) propose that additions to web-based behavioural interventions, such as e-mail counselling, online group counselling, or telephone counselling, can contribute to the clients' participation, engagement, and motivation. The use of technology has the potential of improving the relationship between therapist and client as well as reaching a population that would not have access to treatment otherwise.

There is some evidence that clients can develop good work alliance—a productive engagement between therapist and client—even through remote deliveries. Work Alliance is important because the bond between therapist and client influences the collaboration between them as well as a good relationship has been related to better outcome of treatment (Gaston, 1990). Cook and Doyle (2002) used the Working Alliance Inventory to compare working alliance for individuals receiving online therapy (via email, chat, or audioconferencing with a human therapist) and those receiving face-to-face therapy. The results surprisingly showed higher means for online participants than to face-to-face ones on the goal subscale and composite score. They suggest that, in fact, working alliance can be developed in online treatments even if the communication was mostly made through text chat or email. On the other hand, King and colleagues (2006) compared work alliance in telephone and real-time text exchange in online counselling for young people. Self-reported alliance scores were higher for the telephone counselling group compared to the online one. This remote way of delivering psychotherapeutic treatment still requires a professional's time and attention to interact with a client.

Work alliance can be developed not only when there is a health professional at the other side, but also through automated interventions. Bickmore, Gruber, & Picard (2005) tested how well three automated computer interfaces for behaviour change established working alliance. The control group consisted of web forms only; the non-relational group had the addition of an avatar; the relational group's avatar included social-emotional behaviours (e.g., social dialogue, empathetic feedback, meta-relational communication, nonverbal behaviours as headnods) with the client selecting a response from a multiple-choice menu. The results show that work alliance could be established with an avatar and that the relational behaviours significantly increased the working alliance. Even an automated virtual coach has the potential for establishing work alliance with the client, saving costs and increasing dissemination.

A range of novel tools have been employed to automatize the delivery of motivational support as video doctors (e.g., Gerbert et al., 2003), avatars (e.g., Outlaw et al., 2014), and robots (e.g., Kanaoka & Mutlu, 2015). In our current project, we explored fully automated delivery, independent of a professional at the other end to interact with the client. We investigated interactive designs with both embodied and screened humans and robots as virtual coaches to deliver MI and FIT. Virtual coaches might offer advantages over other forms of technological deliveries. For instance, computer-based virtual coaches training mindfulness are more effective than self-administered training using written and audio materials (Hudlicka, 2013). Substituting traditional videoconferencing for virtual coaches could lower the costs of the intervention and reach more people. However, the design of these virtual coaches can be challenge.

Mori (1970) has developed the uncanny valley theory, in which he shows that a person’s evaluation of a humanlike robot could shift from empathy to revulsion as it tries to imitate humans appearance but fails to do so. Virtual characters might also fall into this hole as their appearance and behaviour differ from the human norm (Tinwell, Grimshaw, Nabi, & Williams, 2011). We explored the acceptability of our virtual coaches considering they could potentiate the connection with the clients but have drawbacks. In order to avoid prompting this eeriness, we chose to utilize humans as video coaches and a stylized robot that does not imitate human's organic forms. Specific background related to these video, holographic-like, and robotic motivators will be presented on the conceptual development section in Chapter 2.

To use these virtual coaches in technological behaviour change devices, we focused on utilizing existing theory-based psychological counselling methods that have been effectively applied in face-to-face interventions, MI and FIT. MI was selected because it is well established and FIT because offered advantages over MI both for behaviour change and for automation.

Counselling techniques for behaviour change

MI and FIT support behaviour change by strengthening motivation as opposed to providing education or advice about change. MI has been shown effective for a range of behaviours (Burke, Arkowitz, & Menchola, 2003) and has already been adapted for an array of technological deliveries (Shingleton & Palfai, 2016). FIT builds on MI by adding mental imagery exercises to the conversational style of MI (Kavanagh et al., 2014). Delivered face-to-face, FIT has been shown to outdo traditional advice (Andrade, Khalil, Dickson, May, & Kavanagh, 2016) and to also produce greater impact in weight loss compared to MI in a controlled trial (Solbrig et al., 2018). FIT uses mental imagery exercises that could potentially tackle the limits of MI's focus on dialogue, which has been a challenge for its technological adaptations because artificial intelligence still struggles to cope with unconstrained human speech.

Motivational Interviewing (MI)

MI is a counselling method initially created to treat alcohol addiction (Miller, 1983), which focuses on a brief empathetic person-centred style that elicits the patient's own motivations for change (Miller & Rose, 2009). This counselling technique arose as an alternative to a confrontational style in counselling that was demonstrated to be counterproductive (Miller & Rose, 2009). MI therapists selectively evoke arguments from the client to strengthen their motivation in a Socratic fashion, that is, a cooperative guided dialogue (Miller & Rollnick, 2004). This counselling technique has been extensively delivered in face-to-face with empirically supported effectiveness in several domains as weight loss (Armstrong et al., 2011), smoking cessation (Heckman et al., 2010; Lindson-Hawley et al., 2015), paediatric treatment (Gayes & Steele, 2014), disordered gambling (Yakovenko, Quigley, Hemmelgarn, Hodgins, & Ronksley, 2015), anxiety disorders (Marker & Norton, 2018) and physical activity (O'Halloran, Shields, Blackstock, Wintle, & Taylor, 2016). By weighing the evidence of four meta-analyses of MI, (Lundahl & Burke, 2009) detected that MI is 10-20% significantly more effective than no treatment in a variety of behavioural problems. The effectiveness of MI comes from a series of ingredients that prompt behaviour change.

The Spirit of Motivational Interviewing with core ideas developed by Miller & Rollnick (2012), comprises four key interrelated elements formed by an experiential as well as a behavioural component: compassion, acceptance, collaboration, and evocation. Four methods were highlighted in the original formulation of MI to help counsellors to achieve the MI Spirit: asking open questions, listening reflectively, affirming, and summarizing (Miller & Rollnick, 2002). These methods help build people's intrinsic motivation in order to resolve ambivalence about behaviour change (Lundahl & Burke, 2009). Behaviour change promotion is achieved by prompting clients to verbalize their arguments for change, which is called 'change talk' (Miller & Rollnick, 2002). In summary, therapist empathy and MI Spirit in conjunction with therapist's use of MI-consistent methods encourage the client's preparatory change talk and diminish their resistance to change. This process is followed by the client committing to behaviour change and ultimately behaviour change itself (Miller & Rose, 2009).

As MI consists of a combination of elements, researchers have been trying to understand which components of this counselling technique lead to positive outcomes. Apodaca and Loganbaugh (2009) reviewed the mechanisms of change in MI, suggesting that the main effective ingredients are the client's experience of change talk and discrepancy. Copeland, McNamara, Kelson, and Simpson (2015) also reviewed MI's mechanisms of change and pinpoint strengthening personal motivation and MI Spirit (collaboration, evoking the client's ideas about change, and autonomy) as the most promising components related to better outcomes. In a multivariate meta-analysis of MI process and outcome, Pace and colleagues (2017) found a significant relationship between MI-consistent behaviours (e.g., open questions; as opposed to MI-inconsistent behaviours; e.g., confrontation) and increased client change talk. In another investigation about MI mechanisms of change related specifically to self-care in adults with heart failure, genuine empathy, affirmation, humour, and individualized problem solving improved outcome as they stimulated self-talk, perceived ability to overcome barriers, and change talk (Riegel, Dickson, Garcia, Masterson Creber, & Streur, 2017). In Apodaca and colleagues' (2016) study, they detected that change talk was significantly more likely to occur after therapists' affirmation, open questions, and reflection; and less likely after giving information and closed questions. These studies suggest that change talk is an important mechanism in MI and that effective therapists are those who elicit lots of change talk from their clients.

Understanding the components in isolation might also facilitate the development of the technological delivered MI. Shingleton and Palfai (2016) created a list of qualities of MI that allowed them to judge the comprehensiveness of technology-delivered adaptations of motivational interviewing (TAMIs), by rating how many components were included in each of the selected studies. Their list included 15 items: (1) develop discrepancy/explore ambivalence; (2) roll with resistance; (3) promote autonomy; (4) express empathy; (5) collaboration; (6) evocation; (7) promote self-efficacy; (8) strengthen commitment to change; (9) ask permission; (10) reflections/summaries; (11) open ended questions; (12) structure adapted to readiness to change/interest/self-efficacy; (13) other MI adherent behaviours (e.g., affirmations); (14) verbatim examples; (15) fidelity measure. They analysed 41 studies and found that none of them included all of the components in their TAMIs. Nonetheless, TAMIs were well accepted and potentially effective in changing target behaviours. They might offer advantages compared to a traditional delivery in terms of decreased therapist time and training investment, and reaching a population that would not have access to this type of treatment. However, most of the reviewed studies did not focus on simulating MI with open questions.

Giving that asking open questions is a core of MI and that this mechanism leads to increased change talk, one of the main goals of this counselling technique, it would be expected that this would be an essential component of TAMIs. Yet, in Shingleton and Palfai's (2016) review, only 6 out of the 41 studies included open questions in their TAMI.

Table 1.1. Studies from Shingleton and Palfai's list (2016), which include open-ended questions with the types of technology included in protocol.

	Text	Audio	Video	Animation
Becker et al. (2014)	✓			
Dilorio et al. (2009)	✓	✓		
Friederichs et al. (2014)	✓			✓
Gerbert et al. (2003)		✓	✓	✓
Osilla et al. (2012)	✓	✓	✓	
Walters et al. (2014)	✓	✓	✓	

Taking an individual closer look at each of the above papers shows that open-questions were far from regularly being applied in TAMIs in a similar manner that they are used in face-to-face MI deliveries. And not all the interventions from this list were based solely on MI. Becker and colleagues (2014) developed a web-based intervention using principles of MI. Their tool was text-based and included some open-questions with tailored feedback. Dilorio et al. (2009) study used a mixture of concepts derived from Transtheoretical Model of Behaviour Change, Social Cognitive Theory, and MI in their webtool for epilepsy self-management. They describe that their webtool had seven components and three modules. Users advance through each of the modules by answering questions related to their behaviour, which elicits tailored feedback. DiIorio et al. (2009) explain that there were some open-ended questions within the modules and the audio component was about listening to stories of others with similar concerns, not related to MI. In Friederichs, Bolman, Oenema, Guyaux, & Lechner's (2014) study, a webtool based on Self-determination Theory and MI for increasing physical activity contained written open-questions, inviting users to type their answers with feedback to their responses. The 'animation' component was not animated, but a static illustration of a character. Gerbert and colleagues (2003) developed a video doctor based on MI with branching pathways to tailor the program accordingly to the users' input to tackle smoke and alcohol consumption. From their descriptions, there were closed-ended questions and they do not mention whether any open question was included. The audio component seems to be the video doctor's voice and they report that they used graphics on the video which might have been considered animation by Shingleton and Palfai (2016). Osilla and colleagues (2012) developed a web intervention with core elements of MI for first-time driving under the influence (DUI) offenders. The web intervention was tailored to participants' responses and videos or audios were used as introduction, giving information or feedback and there were a few open-questions that required participants to type in their responses, even though the program was composed mostly by multiple-choice questions. Walters and colleagues (2014) created a web-based intervention targeting substance abuse in the criminal justice system integrating the Extended Parallel Process Model, MI, and Social Cognitive Theory. They used text-to-speech engine to deliver custom feedback, and a voice speaking questions out loud while users typed or selected their answer. It seems there were some open-ended questions but the majority was multiple choice questions. The video element consisted of testimonials from individuals on probation. The above studies had a lack of clarity in their protocol description of how they used open-questions, some were not solely theoretically based on MI, and none them actually tried to replicate the dialogue mode of MI so there was no attempt to elicit change talk from users.

Open questions are one of the main pillars of MI, and of person-centred counselling generally. They are a key technique for eliciting change talk—one of the main effective ingredients of MI—and an obstacle to adapting this face-to-face counselling method into remote deliveries. While giving the chance for clients to talk gives breadth to understand the full extent of the client's dilemma, reflection gives depth by drawing out and reflecting back the most important and emotional aspects of what the client is saying. Reflection is even harder to automate. The closest attempt to simulate MI with open questions and its dialogue mode utilised a robot as an interviewer. Kanaoka & Mutlu (2015) have used a NAO robot to deliver MI in a similar way of its face-to-face delivery, using a speech recognition system to tailor the interaction. However, there was a lack of fluency in the dialogue between the robot and the participants due to errors in speech recognition and incongruous nonverbal behaviours. The conversational style of MI seems difficult to adapt to technology with the full capacity that this counselling technique is delivered in face-to-face interventions.

Functional Imagery Training (FIT)

The automation of MI poses a challenge to technological translation as it relies heavily on dialogue. While MI attempts to establish a verbal exchange between practitioner and client for motivation and goal setting, FIT builds on MI, developing imagery-based self-management to change behaviour (Kavanagh et al, 2014). MI-style dialogue is important for eliciting ideas about how the participant wants their future to be, how to reach that goal, and how to overcome obstacles and challenges on the way, but Kavanagh and colleagues (2014) propose that MI techniques benefit from the extra boost of vivid imagery generation about the client's goals and pathways to action. Taking the focus away from the dialogue with an emphasis on mental imagery exercises could make FIT a stronger candidate for technological adaptations.

FIT is a motivational intervention based on Elaborated Intrusion (EI) theory. EI theory proposes that intrusive thoughts elicited by external or internal cues are further elaborated with mental imagery that might involve not only sight, but also smell, taste, touch, or hearing (Kavanagh et al., 2005). The EI theory takes into consideration not only thinking per se, but a cascade of sensorial attributes (May, Andrade, Kavanagh, & Hetherington, 2012). Elaboration includes thinking about the ability to obtain the desired object or planning the action to satisfy desire with the help of mental imagery (Andrade, May, & Kavanagh, 2012). The sensory images that have an emotional attribute occur during cravings and other desires potentially lead to behaviour.

Interfering with sensory imagery can work against the elicited cravings, weakening desire (Andrade, May, et al., 2012). An imagery scale of craving alcohol predicted a 12-16% variance in concurrent alcohol consumption, therefore, an early intervention that interferes with imagery could be effective (Connor et al., 2014). Interference with mental images through modality-specific cognitive tasks can suppress cravings by competing for limited capacity of working memory (Kemps & Tiggemann, 2015). Andrade and colleagues (2012a) demonstrated that the use of a clay modelling task resulted in less chocolate craving than a control condition. A verbal arithmetic task did not have the same effect, supporting EI theory's hypothesis that interfering with visual imagery, by loading visuospatial working memory, would reduce craving compared with loading the phonological loop. Other visuospatial tasks, for example, playing the visual videogame Tetris, also reduce craving (Skorka-Brown, Andrade, & May, 2014). Not only can external stimuli and tasks interfere with desire, Knäuper, Pillay, Lacaille, McCollam, & Kelso (2011) also found that self-generated pleasant imagery is effective in reducing craving intensity.

These demonstrations that blocking imagery can reduce cravings show the potential of imagery to influence the process of behaviour change. Andrade, May, et al. (2012) have argued that imagery can be used to strengthen functional desires, as well as to weaken unwanted cravings. The capacity of clients to visualize goals can compete, mentally, with the temptations of the desired object making FIT potentially more powerful than MI alone. Sensory imagery provides a base for motivation as it unfolds into a series of emotional qualities that influences desire (Andrade, May, et al., 2012). Cole and Berntsen (2016) elaborated a paradigm to examine mental time travelling through autobiographical future thoughts compared with autobiographical memories.

They detected that future thoughts elicited voluntarily or involuntarily are more likely to reflect current concerns than memory of past events, i.e., are relevant for goal-directed cognition and behaviour. Mental imagery can strengthen implementation intentions by producing higher rates of goal achievement (Knäuper, Roseman, Johnson, & Krantz, 2009). These findings suggest that the use of imagery in FIT would boost its efficacy compared with MI. Another advantage of an imagery-based intervention like FIT is that it should be less dependent on verbal dialogue, making it easier to adapt into technological delivery.

Initial empirical testing of FIT has used traditional face to face delivery. FIT delivered in one single session followed by booster phone calls reduced snacking and participants lost weight compared to a control group (Andrade et al., 2016). In a randomised controlled trial, two face-to-face FIT interviews plus nine booster calls over six months resulted in greater weight loss compared with the same amount of MI (Solbrig et al., 2018). FIT has not only been applied in the clinical setting but also in sports. FIT was shown to increase grit in professional soccer players compared to a control group who received no intervention (Rhodes, May, Andrade, & Kavanagh, 2018). The professional players also perceived that FIT improved their sport performance. These first empirical tests of FIT reveal clinical potential compared to traditional advice and even to MI, and show its potential in other areas such as sport performance. FIT also seems promising for virtual delivery. When presented with FIT app screen shots, focus group participants who were trying to lose weight felt that it could be a valuable skill to help them sustain motivation (Solbrig et al., 2017).

Although FIT has not yet been fully delivered through technology, researchers have been applying other mental imagery techniques remotely. Lang and colleagues (2012) developed a computerized program using positive mental imagery for depression with an effective outcome with participants showing improvement of intrusive symptoms compared to a control condition. Murphy and colleagues (2015) included the same positive imagery training in a computer-based cognitive training for older adults which resulted in an increased vividness of prospective imagery compared to a control group. Blackwell and colleagues (2015) also used positive mental imagery in a web-based treatment for depressed adults with participants showing improvements in anhedonia and other symptoms compared to a control condition. These studies show that imagery exercises can be delivered remotely but a more ambitious, remotely-delivered imagery-based counselling session has not been attempted.

Summary

In summary, technological deliveries of healthcare have the potential to unleash the health system as well as empowering people in their treatment. Supporting behaviour change can ultimately help reduce demands on healthcare. MI and FIT are motivational counselling techniques for behaviour change that offer ingredients translatable into technologies. Researchers have attempted to adapt MI to different forms of remote delivery but have not fully captured the effective ingredients of this counselling methods as an interactive delivery where clients engage verbally. FIT complements MI's principles by focusing on mental imagery exercises, which can facilitate its adaptation into automated-remote support.

The next chapter will delineate the conceptual and technological development of the empirical studies to implement concepts presented in this chapter. We present the developed types of technology (pre-recorded video and robotic coaches) as they could plausibly provide similar interactions as the traditional face-to-face session or even enhance the delivery of MI and FIT.

Chapter 2: Project Development

CogNovo[1]

The context in which we have operated in CogNovo was a cohesive international interdisciplinary research community. We were a group of twenty-five PhD fellows working on projects related to creativity and innovation. We have had a workshop-week every three months in which we worked together in groups, creating practical projects such as a radio show and a short film work related to the workshop themes. The following topics were discussed during those weeks: Research Methods, Experimental Methods, Computational Modeling, Public and Social Innovation, Entrepreneurship, Social Creativity, and Humanities Perspective.

Besides being part of this network of researchers who were closely exchanging ideas, interdisciplinary skills were highly encouraged within each project, for example by including supervisors from different disciplines in each supervisory team and recruiting PhD fellows who demonstrated aptitude for interdisciplinary research. For myself, I tried to combine my previous experience as a filmmaker with my background in experimental psychology to create a unique research project. The creative and encouraging atmosphere for new ideas has been tremendously inspiring for coming up with original solutions in this current project.

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[1] EU FP7 Marie Curie Initial Training Network (FP7-PEOPLE-2013-ITN-IDP 604764, **€4.1m** "CogNovo: Cognitive Innovation". Denham S (Coordinator, Plymouth University); Andrade J, Belpaeme T, May J (Plymouth), Kavanagh, DJ, Tjondronegoro D (Queensland), Baillie JC (Aldebaran): Project 13. Using creative technologies to promote behaviour change. 2013-17.

Interdisciplinarity

CogNovo’s interdisciplinary premise was established since its conception as a doctoral training programme where every student would be supervised by representatives of different research fields and would engage in training on a wide variety of methods through the project’s workshops. Potential students were assessed for their aptitude as interdisciplinary researchers. In my own case, I have a background in professional football and film-making, as well as psychology. The terms creativity and innovation were brought together in a way of establishing the core of the program, a holistic view denominated 'cognitive innovation' (Gummerum & Denham, 2014). CogNovo aimed at bringing together psychology and neuroscience with arts and technology. Gummerum and Denham (2014) argue that the strength of CogNovo is exactly the commitment to permeate disciplinary blinkers in order to lead to a broad understanding of cognitive innovation. The dissolution of boundaries between different fields of research from psychology to robotics informed this project from the beginning. Several methods were used to foster collaboration and the interdisciplinary identity of the group as (1) What's Up, a weekly time slot to present new ideas, technical, and methodological background or start a discussion about some interesting topic; (2) communal seminar room which became an improvised atelier for experimenting with ideas and materials also displaying students' posters, (3) all students housed together in open plan office space, (4) website with news and public engagement.

Project 13: Creative Technologies for Behaviour Change

Project 13 was advertised with the name of Creative Technologies for Behaviour Change with supervisors from cognitive psychology (Jackie Andrade and Jon May, Plymouth University), clinical psychology (David Kavanagh, Queensland University of Technology), and robotics (Tony Belpaeme, Plymouth University). The initial idea for the project was to explore ways in which technology could be helpful in motivating people, encouraging them to change behaviour potentially through mobile apps and robots. The initial purpose of this project was to integrate ideas from behaviour change, new use of technologies, and social robotics.

Conceptual development

The original plan for this project was to work with the tools with which the supervisors had expertise. Jackie Andrade, Jon May, and David Kavanagh brought their know-how in behaviour change which they had already applied to web and mobile interventions as the OnTrack, a website aiming to support the Australian community with services to help mental and physical wellbeing with programs to treat alcoholism and depression among others, and a FIT app, Goal in Mind (Goal in Mind, n.d.), helping people to monitor and practice mental imagery for behaviour change. Tony Belpaeme came from a background in robotics and offered to facilitate the use of humanoid robots for this project. While I had acquired a bachelor’s degree in psychology and master’s in neuroscience prior the commencement of this project, I had also an antecedent experience in filmmaking and multimedia.

The initial step was to understand the tools and skills available and the conceptual significance of the employed disciplines in order to approach the project and define how to implement them into a feasible strategy. As cited in the previous chapter, we considered how technology could help deliver these counselling techniques, developed for face-to-face delivery, to wider audiences.

With my background in filmmaking, I felt comfortable starting with video as a type of technology that could serve as a motivational tool in a way that had not been previously produced. Although video had been used before to help elicit motivation, we brainstormed ways of combining psychology and technology to make a more general, sustainable and interactive intervention. As MI is based on dialogue and other attempts of automating this counselling technique did not fully explore this domain, the possibility of creating a two-way simulated interaction through video became a potential solution in trying to replicate the MI original dynamic.

The use of video in psychology has been explored in diverse ways. The advent of cinema and then television in the past century has brought a sense of familiarity with people being projected from a screen. With the ubiquity of the Internet, therapists have gained another form of reaching their clients. Kotsopoulou and colleagues (2015) cite the emergence of the e-therapist who is in touch with their clients by electronic means not limited to geographical boundaries. Telepsychotherapy encompasses psychotherapy conducted by a therapist from a different location than the client being supported by real-time interactivity (Kaplan, 1997). Capner (2000) reviewed the literature on videoconferencing in the provision of psychological services at a distance and noted that it is a new and potentially beneficial to bring such services to isolated communities. Besides the technology-powered video contact with a therapist live at the other end, automated interventions incorporate video into their methodologies. Shingleton & Palfai's (2016) review points to 14 studies that integrated video into remotely delivered interventions based on MI. A closer read to each of the papers cited by Shingleton and Palfai (2016) show that some of the studies which used video as part of a virtual intervention do not describe in detail the content of the videos or how this element was inserted. For example, Kay-Lambkin et al. (2009) reported a computer-based intervention for comorbid depression and problematic alcohol and/or cannabis use, which included video clips. Naar-King et al. (2013) developed a computer-delivered prevention intervention for youth newly prescribed antiretroviral treatment including video insertions with no further explanation of its contents. Video clips were also mentioned as part of the web-based chronic pain management intervention (Nevedal et al., 2013).

Two studies from Shingleton & Palfai's (2016) review list adopted videos in the intervention to model behaviour. A computerized intervention for cannabis use disorder employed video-based simulation played by actors who modelled coping behaviour as for instance drug-refusal skills (Budney et al., 2011). Walters and colleagues (2014) developed a modelling web-based intervention for substance abuse in the criminal system with video testimonials from other individuals on probation.

Other studies from Shingleton and Palfai's (2016) list utilized videos as an introduction to the intervention or other excerpts with further information.

Ahmendani et al. (2015) tested a brief tailored mobile intervention for depression among patients with chronic pain based on MI and cognitive behavioural therapy. One component of the intervention was video clips of a physician explaining depression and pain and how to improve their condition. Participants rated these videos highly. On the same line, a computerized brief intervention targeting a tobacco addiction recovery cohort included a video of a medical practitioner who advised participants to quit smoking based on a non-confrontational approach (Breland et al., 2014).

There were also attempts to make the intervention more dynamic through videos. A brief MI intervention for HIV high risk offenders utilized video clips for questions and computer entries for answers (Alemagno et al., 2009). Gerbert and colleagues (2003) included a video doctor to deliver brief smoking and alcohol virtual intervention. Actors portrayed video doctors in a script based on MI for a library of digital video clips that contained several questions and intervention pieces. The tailored interaction was based on participants' responses that were acquired from multiple choice selections on the screen. They emphasize that the multimedia video doctor could be a powerful tool in remote health interventions. Markham et al. (2009) included an expert introductory video in a computer-based HIV prevention intervention with elements of MI. Osilla et al. (2012) developed a web-based MI for first-time DUI offenders with videos introducing and summarising the content of each section as well as tailored reactions to written responses. A video interviewer that was part of a computer-delivered MI intervention for high-risk drinking appeared periodically with welcome messages, instructions, encouragement, and feedback

(Wagener et al., 2012). These attempts to dynamise the MI interaction with video counted on a mix of technologies mainly with responses in text.

As video was used as one of the elements of many of the interventions, the video counsellors in isolation have not been tested to show its efficacy compared to other mediums. However, there were multiple citations of the video technology being positively praised and well accepted by the participants (e.g., Gerbert et al., 2003; Markham et al., 2009).

The video doctor technology has been applied to a range of behaviours which, in most cases consists of a video inquiry followed by a web-based response by the participant. Low-income women changed their dietary habits and increased their exercise during pregnancy with a brief video doctor intervention compared to usual care (Jackson et al., 2011). Tsoh and colleagues (2010) utilized a video doctor to promote smoke cessation in pregnancy with efficiency. Arora and colleagues (2013) employed the video-doctor technology to increase cancer screening. Boß and colleagues (2015) included videos as part of an internet-based self-help for alcohol abuse and a protocol to evaluate the effectiveness of a guided and unguided delivery being the professional assistance by text. Although there are constraints on virtual delivery through video compared with what a real encounter and interaction can provide, Gerbert and colleagues (1999) report that patients provided greater risk disclosure to a video counsellor than in traditional methods. Furthermore, Gilbert and colleagues (2008) also developed an interactive video doctor counselling that reduced drug and sexual risk behaviours among HIV-positive patients.

The only MI videos available on YouTube were based on role-playing MI as a training for counsellors in delivering this brief intervention face-to-face. No online platform offered a video-interactive MI. The previous attempts to mechanize MI through video showed the potential of greater disclosure and acceptance of this type of delivery but lacked a verbal exchange. Because participants responded with text, the interactions lacked one of the principal elements of MI, change talk. As cited in the previous chapter, one of the most effective ingredients of MI as mechanisms of change are the client's change talk (Apodaca and Loganbaugh, 2009). It therefore seemed important to give people the opportunity to talk about their experiences.

The question now was how to encourage people to talk to the technology and how to make it listen to them, as other attempts to mechanize MI had not used videos in a dynamic manner, simulating the actual dialogue. Asking open questions leaves little control over the range of possible responses, and current speech recognition AI copes poorly with unconstrained input. For TAMIs that offer a range of responses depending on the participant's input, open questions are a problem. We turned the problem around by constraining the TAMI to a single path of questions, leaving the participant free to talk about whatever they wished. Potentially, this approach could bring the benefit for participants of hearing themselves arguing aloud for change, but at a cost of the interview feeling less personalised. Study 1 (Chapter 3) addressed these issues by examining the extent of change talk in TAMI-human interactions and exploring participants' experiences of the interaction.

The puzzle was how to deliver this video intervention automatically without the need of human support. Other researchers had been using 'video doctors' as Gilbert and colleagues (2008), translating MI concepts to this type of technology, prompting a response in text. We could use a human video counsellor that would simulate that they were 'listening' to the client. This strategy would give clients space to express their motivations, goals, and plans for change. Thus, I proposed a simple interface in which pre-recorded videos of a human video coach would ask questions and a 'listening' video would give the impression that the counsellor was paying attention to the response. The client would have the autonomy to click on a button to advance to a next question in a straightforward and easy-to-use mechanism. The 'listening' video would be on a loop to accommodate the fact that we could not predict how long each participant would spend answering each question.

Poppe and colleagues (2011) point out listening as an important aspect of a conversation conveying attention, interest, and understanding of the speaker. They explore a specific type of signal called backchannel, i.e., short visuals as nods and smiles and vocals as 'uh-huh' and 'yeah' from the listener that do not interrupt the speaker. Poppe and colleagues (2011) tested the timing, type, and quantity of backchannels delivered by technology and real speakers to approach a human-like response. They found that nods were more appropriate than vocalizations and that, for quantity, too few or too many backchannels per minute reduced the quality of it. Hence, we designed our 'listening' video with the aim that the video counsellor would show empathy with a limited number of nods and no vocal response in order to avoid major contradictions between what a participant could say and the pre-recorded response of the human counsellor.

We technically developed this proposal, firstly testing potential counsellors and later recording a final MI script, based on the core values of MI. We tested the dynamic video intervention in a qualitative study described in detail on Chapter 3. Through CogNovo events, being in touch with NAO robots, I learned about their capabilities and realized that we could apply the same methodology to robot counsellors by utilizing the same MI script. We could implement the same concept in a face-to-face MI with a NAO robot, which we tested in another qualitative study to test if participants would engage with the robot and whether they found the interaction acceptable and effective (Chapter 4).

Costescu and colleagues (2014) performed a meta-analysis of studies about robot-enhanced psychotherapy. They found that most researchers focused on the robotic development rather than the psychological outcomes and there was a lack of studies reporting quantitative data, leading them to include only 12 studies out of 861. These 12 studies varied in tasks (e.g., visual, cooperation, attention, interaction, learning, puzzle-solving, role-playing, cognitive) and measured outcomes (e.g., response time, concentration, eye gaze). The results show that there is a medium significant effect of robot-enhanced therapy on improving performance in three levels (behavioural, cognitive, and subjective) when compared to a nonrobotic condition (e.g., human condition). None of the studies applied counselling techniques for behaviour change. Libin and Libin (2004) coined the term robopsychology, pointing to the bond of these two disciplines. Rabbitt et al. (2015) indicate that mental health care can be benefit with the new area of social assistive robotics (SAR) by expanding robots to a range of clinical applications. The application of robots in therapy that requires dialogue has been restricted as robots have limited speech processing capabilities. In particular, current artificial intelligence struggles to cope with unconstrained input (Cantrell et al., 2011). Kanaoka and Mutlu (2015) designed and evaluated a motivational agent for encouraging physical activity using a NAO robot. They did not find any difference between MI in comparison to a traditional advice condition. However, there was an inadequacy of fluency in the dialogue between the robot and the participant in the MI condition as the speech recognition is limited with backchannel interruptions, breaking the illusion of the social interaction. The participants in the traditional advice condition even rated the robot as friendlier and were more willing to receive advice compared to MI, showing that the monologue was preferred than the broken dialogue.

Looije and colleagues (2010) used a persuasive robotic assistant for health self-management of older adults. They implemented MI techniques to use in a physical iCat, virtual iCat, and text interface. Participants found the physical and virtual character more empathetic than the version in text. Bringing virtual beings to delivery MI in the form of video coaches and robots could increase the empathy between interviewer and interviewee, potentiating the mechanical delivery of this counselling technique which was the aim of our studies. For our robotic application detailed in Chapter 4 and 6, we chose to develop a simpler interface not based on speech recognition but that would give space to the participant to have the autonomy of talking freely and deciding when to advance to a next question inspired by the previously developed video coach's interactive design.

My supervisors—Jackie Andrade, Jon May, and David Kavanagh—have been developing a counselling technique called functional imagery training (FIT) which is built on their Elaborated Intrusion theory (Kavanagh et al., 2005) and that potentializes the MI principles with mental imagery exercises to strengthen desire and counterbalance intrusive multisensory cravings (May, 2012) as cited in the previous chapter. We incorporated FIT scripts into the technologies that we had been developing to investigate whether imagery exercises would have a higher impact than MI. Not only should the mental imagery elicited in FIT potentiate the impact of the intervention, but this motivational technique could be more translatable into technology as it relies less on dialogue. FIT was incorporated to a video robotic interaction detailed in Chapter 6 and a minimal version through a 2D coach reported in Chapter 7.

Walking through Bristol airport, I encountered a virtual video assistant in the form of a hologram-like projection made of an acrylic silhouette cutout. Being in the CogNovo programme helped me to be more aware of the possibilities presented by the environment and to envision this type of technology as a possibility for innovation within my project. The set-up consisted of a real-size woman projected onto her silhouette in acrylic, giving an impression of presence. Intrigued by the attention of the passengers, I realized that we could develop a similar apparatus to explore the limits of projection technology in delivering our counselling techniques.

Many companies have been selling what they commercialise under the name of virtual assistant or virtual mannequin. I only found a similar holographic-like 2D set-up in the research environment by Luévano and colleagues (2015) that applied this technology in the classroom in formal classes at a university level at the Tec de Monterrey. They developed a holographic-like 2D projection that consisted of a projection foil adhered on a 180 centimetre in height rectangular 12mm glass in which was projected a professor's image. Luévano et al. (2015) reported that 65% of students stated paying more attention to the professor on the holographic-like screening than using a telepresence robot. A handful of companies have been producing these virtual assistants consisting of full body projection in 2D. Tensator claims that virtual assistants are ten times more effective influencing behaviour change compared to other forms of digital signage (Tensator, n.d.). They also assert that the virtual assistant used in commercial ways increase unit sales by 75%. From a case study with Network Rail on trying to make people with heavy luggage use the lift instead of the escalators, the virtual assistant was able to increase the number of passengers using the lifts at Kings Cross by 260% (Tensator, n.d.). Another company, Virtual Mannequins, claims their virtual assistants increase traffic and dwell time by up to 50% (Virtual Mannequins, n.d.). There is no scientific research backing up these data and no studies were found with the use of these virtual assistants in health research, which opens up the question whether they could be acceptable and efficient virtual coaches.

This virtual assistant set up in display at the airport was available from Tensator for about £10,000. Even though companies have been selling the development and complete set of virtual assistants, other businesses offer rear projection film for making such a 2D projection. Glimm trades their rear projection film to create virtual mannequins. 3M has even provided a manual entitled Creating a Virtual Mannequin using 3M Vikuiti Rear Projection film (3M, n.d.), making it accessible for the production of the same concept independently, which can lower the costs of manufacture to be applied in research. To explore this possibility, I learned the basic techniques of that sort of equipment and was able to produce a similar tool for less than a couple hundreds of pounds.

This project explored an array of technologies to be potentially used to deliver diverse counselling techniques in a low cost. This was the particular aim of this project: to automate behaviour change interventions that could possibly reach a greater number of people and captured the benefits of counselling techniques that have been usually delivered face to face. The interventions prototyped here offer some particular aspects that can be further developed. Therefore, this project proposes an initial step in developing this sort of behaviour change technology, providing a starting point for more rigorous testing.

Technical Development

This section explains the detailed process of developing each type of technology, not only to make the techniques available and studies reproducible, but also to describe the obstacles faced as considerable problem solving was needed in each step of this project. The aim is to provide a guide so future researchers can apply the suggested ideas, avoiding the difficulties that we have encountered, or creating better solutions to the restrictions faced in this type of intervention.

Video

We developed a MI script to be delivered through a video counsellor. The MI script conception is detailed in Chapter 3. In a small studio with a green screen part of the psychology department (Figure 2.1), I recorded a PhD colleague reciting a short excerpt from the MI script—one sentence—to test how it would be possible to develop such a virtual interview.

Figure 2.1. Video capture room part of the Psychology Department.

Chroma key is a technique in which one applies a green or blue background that can replaced with other images or videos with postproduction techniques. I tested different possibilities, adding different types of background; an initial idea was that the client could choose the environment in which the coach would be located (Figure 2.2).

For this process, I utilized Adobe Premiere for video editing and Adobe After Effects for creating the chroma key effect, extracting the background from the subject. Although Adobe Premiere offers chroma key video effects, it is not as precise and efficient as Adobe After Effects. The following steps were taken in Adobe After Effects to reach a satisfying result: (1) utilizing the 'selective colour' effect to enhance the contrast of the background, tweaking the green colour by adjusting cyan, magenta, yellow, and black (CMYK) channels; (2) applying the 'keylight' effect, a chroma key tool for removing specified colour and using a combined matte view to achieve the final adjustments through screen gain, balance, and other provided tools; (3) adjusting contrast and brightness; (4) adding a new light with an ambient effect.

Figure 2.2. Testing the operationality of the green screen technique with different backgrounds.

Even though the idea of different backgrounds was explored, we decided to focus on developing a video-dynamic MI first, to test the interview in isolation before incorporating other variables to be tested.

The small studio room at the Psychology Department was not ideal for the final recording as there was not enough space for recording a medium shot, only a close-up. I undertook training to be allowed to use the Plymouth University's TV studio room (Figure 2.3). After some initial tests with light and types of shots, I selected a group of potential video coaches to be chosen by participants as the official MI interviewer. Recording with several coaches, besides testing their performance, I could also assess the operability of the system. I have selected three PhD researchers who felt comfortable in this role and willing to be recorded, a lecturer in counselling recommended by my supervisor, and an undergraduate student in theatre who replied to an enquire to Plymouth acting students.

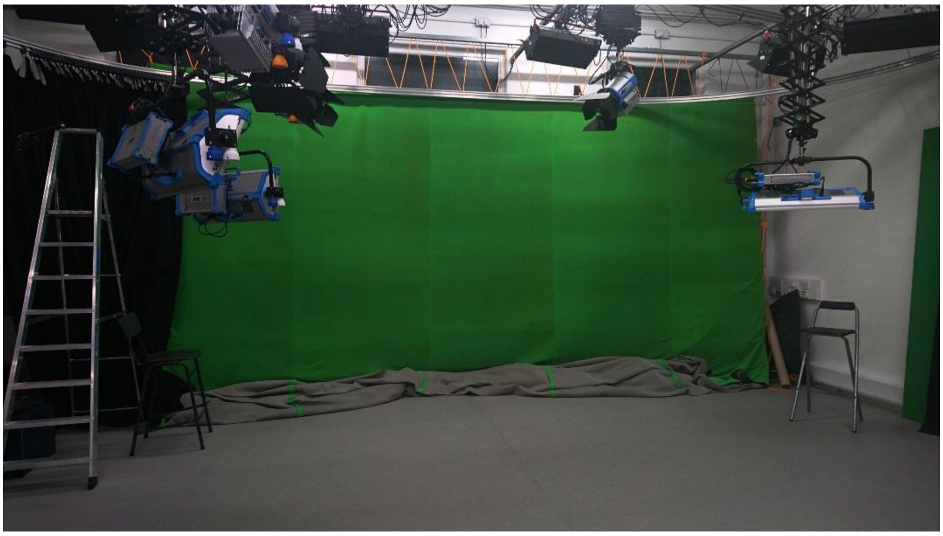


Figure 2.3. TV Studio with a green backdrop at Plymouth University.

I selected a longer excerpt from the MI script consisting of two long sentences, with the duration of about 20 seconds: 'You don't have to be 100% confident to get started—you just need enough confidence to take the first step.

If you don't feel confident enough to start just yet, try thinking about what you can do, so you can become a bit more confident.'

I advised each potential coach to learn the piece by heart. On the recording day with each of them, I asked the person to look directly at the camera and say their lines aloud with a neutral facial expression plus a warm and empathetic tone. This simple recording was more challenging than expected. Most of the potential counsellors were not familiar with the camera dynamic and it took them almost one full hour to say the exact text with no errors. The main problems they faced were keeping their gaze directed at the camera during the whole interval and speaking the two sentences with no mistakes.

I captured the audio with a lapel microphone connected to the camera. In post-production, I substituted the background by a neutral grey backdrop. We decided to make the video counsellor scheme as simple as possible with a neutral background. In the first stage of the research, we set up an online survey in which participants could answer about the acceptability of the coach, 'How empathetic did you find this virtual coach?', 'How trustworthy did you find this virtual coach?', 'How much did you like this virtual coach?', 'Would you like to have this person as your virtual coach in a health intervention?'. The participants were asked to rate the five video counsellors' performance and rank their order of preference from (5) most liked to (1) least liked. Eighteen participants took part of this pilot study. Decisions were made based on the overall mean rank of each video coach. The preferred video coach had a mean total score of 3.61 while the second favourite received 3.56. Both of them performed satisfactorily in the video recording trial and could be the potential video coach. However, the preferred one had the advantage of not wearing glasses compared to the second favourite to read from the teleprompter as the reflection from the lenses influences the recording.

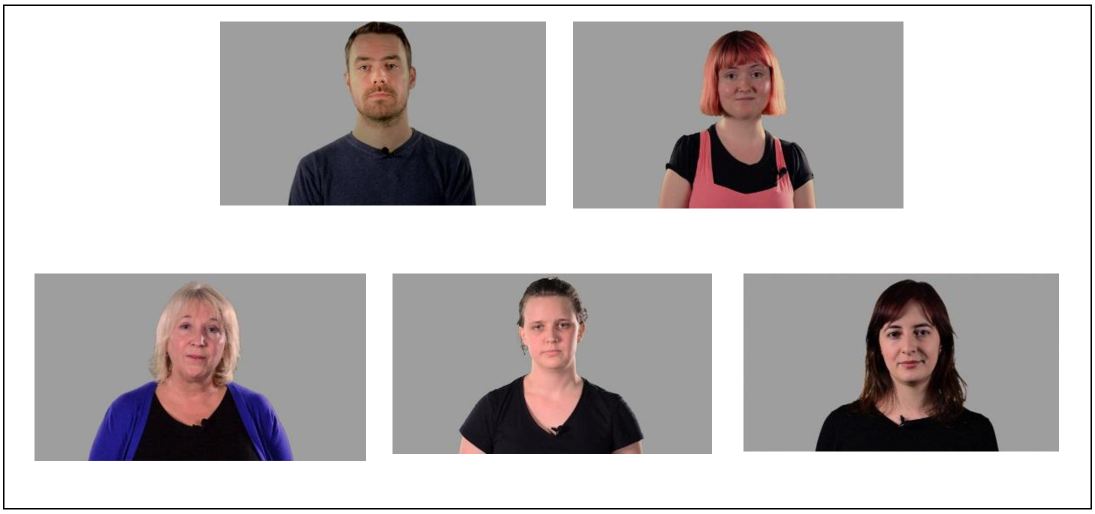


Figure 2.4. Frames of the five potential video counsellors.

The preferred video counsellor was selected for recording the whole script. The difficulties faced in the initial recordings led us to acquire a teleprompter kit for the next stage. The teleprompter consists of a mirror in which a projected text does not affect the video capture (Figure 2.5). We utilized the Teleprompter Pro App, a professional teleprompter system for Android operational system. The app allowed us to import the full MI script, reflect it in mirror mode, adjust the speed and size of the text, and brightness control.

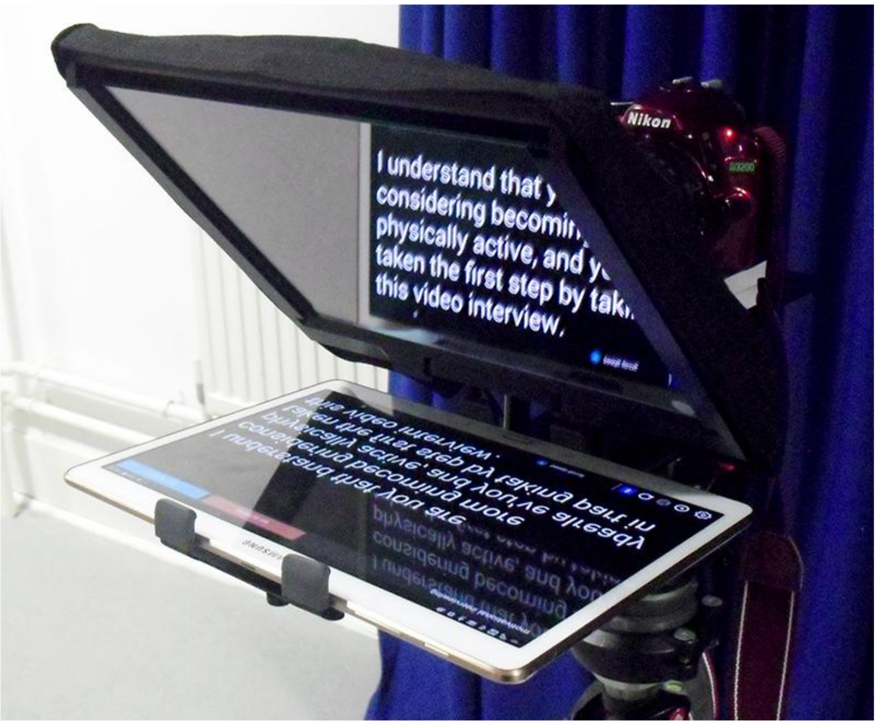


Figure 2.5. Teleprompter projecting the script of the virtual intervention.

The whole script was recorded with several takes for each chunk of text. (see a weblink in Appendix 2.1 with a sample of the MI video coach). A five-minute 'listening video' was recorded in which the video counsellor looked directly at the camera with occasional nods, maintaining an empathetic facial expression (Appendix 2.2 contains a weblink to a sample of the 'listening' video). I edited the takes in postproduction, generating a video for each question and a final 'listening' video with a grey background. For a clearer audio, I utilized the DeNoiser audio effect in Adobe Premiere. The School of Psychology's Technical Office programmed the dynamic interview. I instructed them to play each question in a video frame together with a webcam live projection of the participant, simulating a similar interface as video telephony software such as Skype. While the participant would be speaking their answers aloud, the 'listening' video was played and looped when necessary. Participants pressed a button to advance to the next question. We tested this dynamic motivational interview with a video counsellor in Study 1 (Chapter 3).

Robot

We implemented the same MI script to a NAO robot, having been taught how to program the robot by colleagues in the University of Plymouth's Centre for Robotics and Computational Neuroscience. The software used to program the robot was Choregraphe, which allows the user to program and monitor the NAO robot wirelessly.

To simulate a face-to-face interaction, we worked with two pre-programmed functions that were present throughout the interview. The first one was the breathing function, which simulates human breathing; giving an impression that the NAO is alive. It consists of gentle moves from side to side with the breathing function playing in loop. The second automatic behaviour was the face tracking function, which allowed the robot to detect and track participants' faces. This function gave the idea that the robot was constantly keeping eye contact with participants, mimicking an action that is common for humans in an interview.

We began the encounter with a hand wave and verbal greeting by the robot, followed by an introductory text. The speed of each set of questions was controlled for ideal comprehension. We found that a setting of about 80% as speed percentage was effective in the majority of the text with some further adjustments for other specific pieces. We programmed the head sensor to advance to the next question once touched and instructed participants accordingly. The aim was to produce speech that was easily intelligible but still sounded robotic to maintain the illusion that the robot was talking directly to the participant rather than merely being a mouth piece for a pre-recorded human.

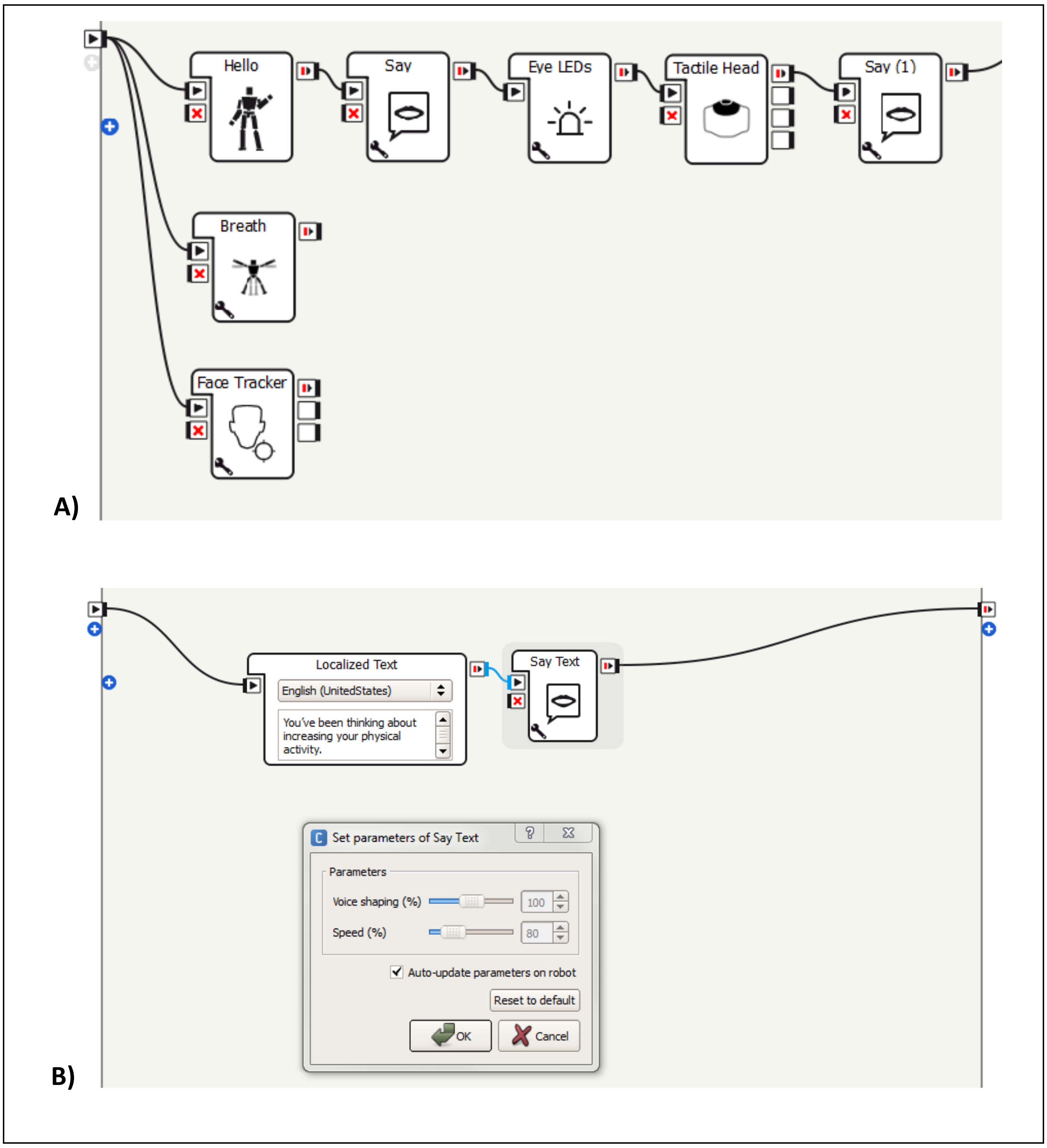


Figure. 2.6. Partial screenshot of the Choregraphe software. A: Initial sequence of behaviours executed by the robot. B) Detail of a say text box with the parameters for voice shaping and speed.

During the robotic motivational interview, the experimenters stayed in a room next to the one in which the participant was with the robot. The robots' eyes contain a camera in which the participant could be observed by the experimenters on the Chroregraphe's monitor screen while there was no audio input. Thus, the experimenters could monitor whether the interview was occurring adequately.

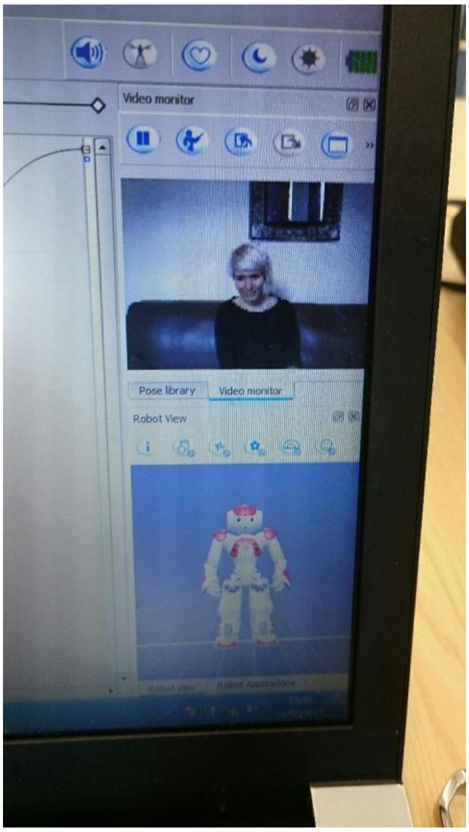


Figure 2.7. View of the experimenter's laptop on the Choregraphe software's video monitoring with the image of the participant projected, captured by the NAO robot's camera eyes in the next room.

In a further development of the robotic interview, we produced a video version of the motivational interview and functional imagery training for a trial. The robotic video automates the process, without the need for experimenters to monitor the robot. As participants did not evaluate positively the webcam component (Study 1), we developed a simpler interface with no live projection of the participant. The robot video aimed to capture the advantages of the robot versus the human counsellor while taking a step towards the goal of a fully automated e-Health application that could be widely disseminated.

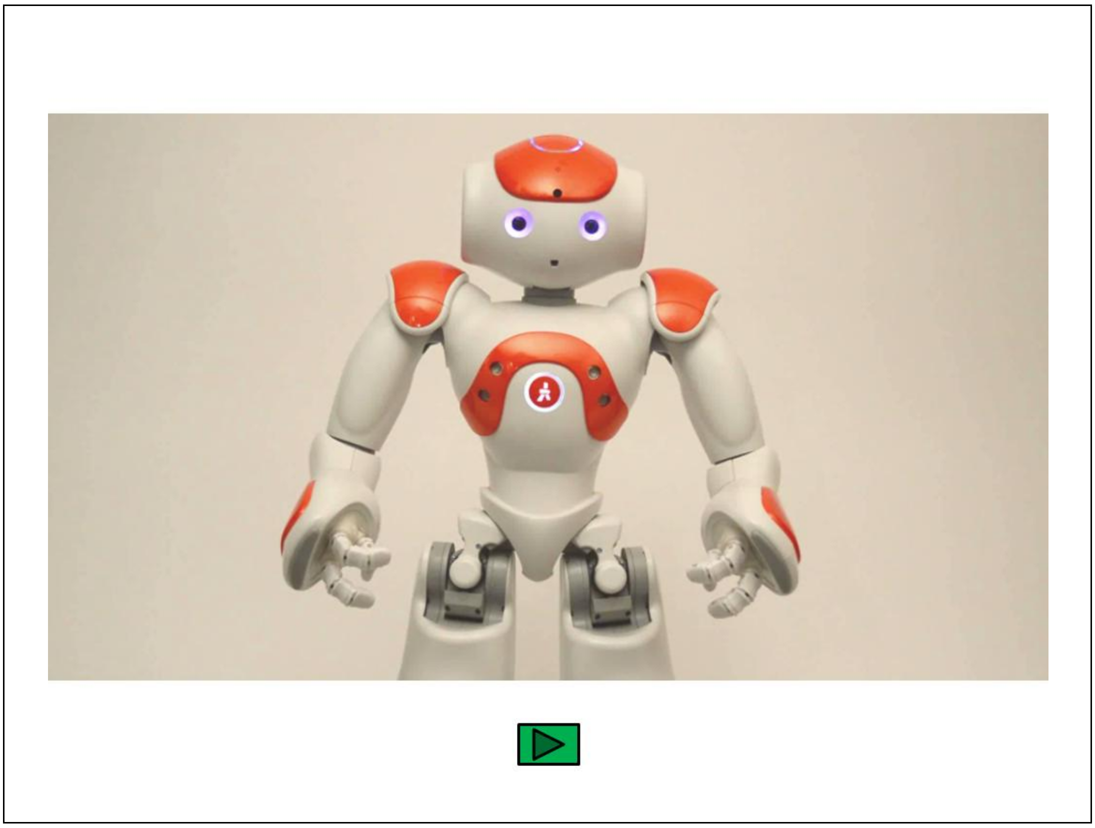
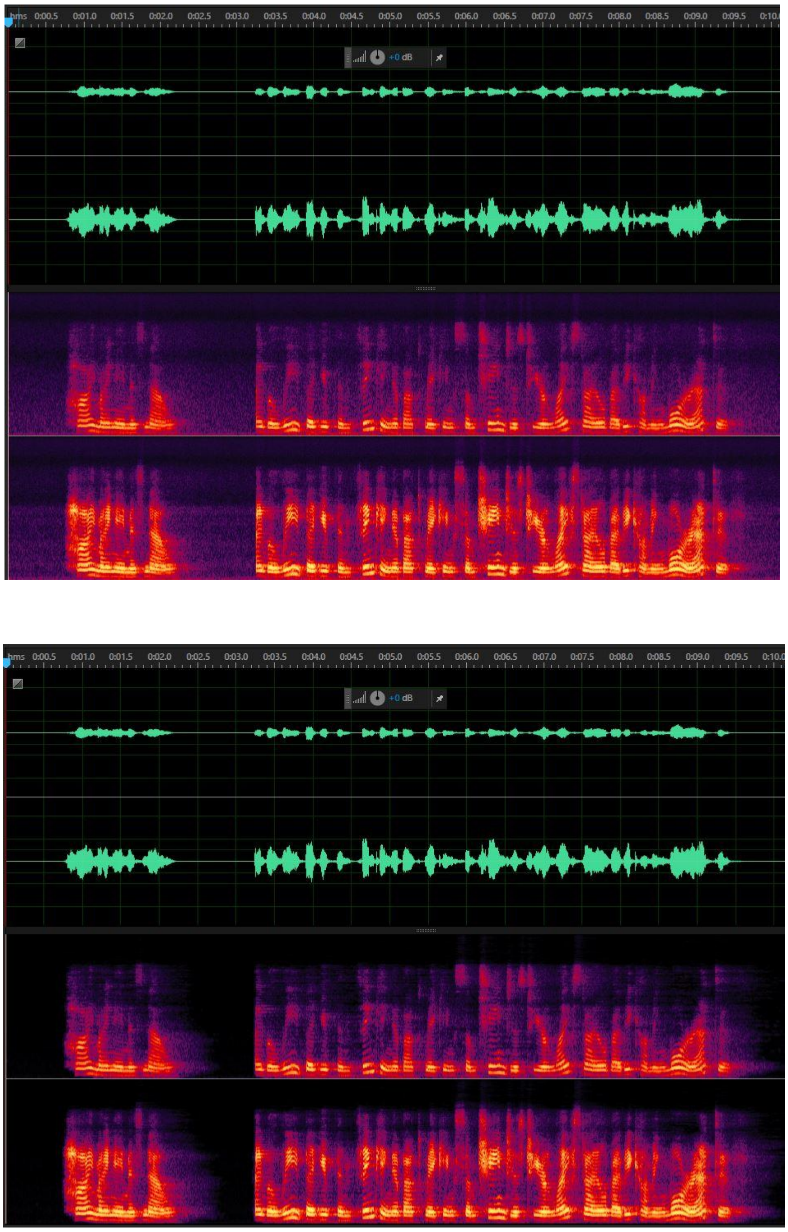


Figure 2.8. The minimalistic design of the robotic video interview with a button to advance to the next question.

For the video version of the robotic intervention, the audio recording was more challenging. The microphones were highly sensitive to the robot’s motor. The DeNoiser effect from Adobe Premiere was insufficient to remove the background noise and clear the audio. I employed a further step on Adobe Audition. With the time-selection tool, a part of the audio that presented ambient noise was selected. I captured this selection as a noise print followed by applying a noise reduction default process for a clearer sound, making the robot's voice stand out and getting rid of the background noise.



A)

B)

Figure 2.9. Partial screenshot of Adobe Audition software. A) Sound before the effect in which the purple blurbs show the noise when the sound should be silent. B) Sound after noise clearance with the black areas marking the silence between the sentences.

With the processes described above, we developed a face-to-face robotic intervention based on an MI script for Study 2 (Chapter 4) and a video version of using both MI and FIT script for Study 3 (Chapter 6). Appendices 2.3 and 2.4 contain weblinks with samples of the video robotic interventions from Study 3.

2D coach

The aim of the projected counsellor was to create the sense of interacting with a counsellor who was physically present. In order to create the 2D coach, I developed some initial prototypes. I undertook a laser cutting short course at the Plymouth College of Art to learn the process of generating a cut from an acrylic sheet. An outline of the video counsellor was traced using Adobe Photoshop from a frame taken from the recorded video. I then drawn the outline in Adobe Illustrator, the file type that is usually acceptable by laser cutting machines (Figure 2.10).

Figure 2.10. Silhouette outline in Adobe Illustrator for the laser cutting machine.

A prototype was developed in 3mm clear acrylic of a silhouette cut out with 60cm high. For the projection to be effective, I applied a projection screen self-adhesive optical rear projection foil for passive 3D to the acrylic clear piece.

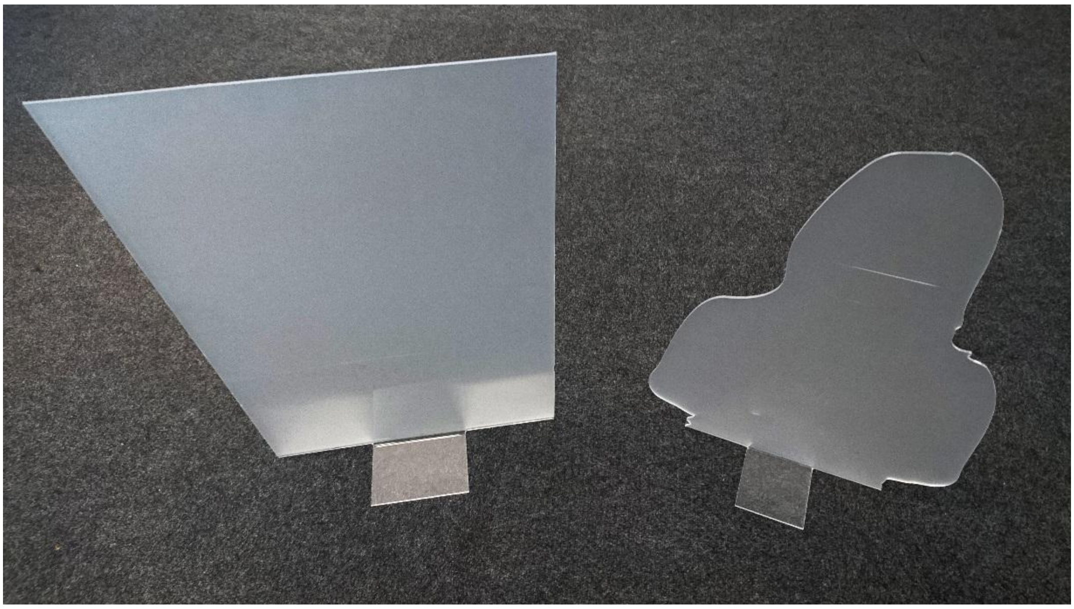


Figure 2.11. Acrylic cut-out in a rectangular form and as a silhouette with the rear projection foil applied to it.

We also tested an acrylic cut in a rectangular shape (66cm by 44cm) and found that did not produce the same enhanced holographic effect as the silhouette (Figure 2.11). I presented the first holographic prototype in the RDC2 (Confirmation of Route) presentation (Figure 2.12). Appendix 2.5 contains a weblink to a video sample of the 2D coach prototype.

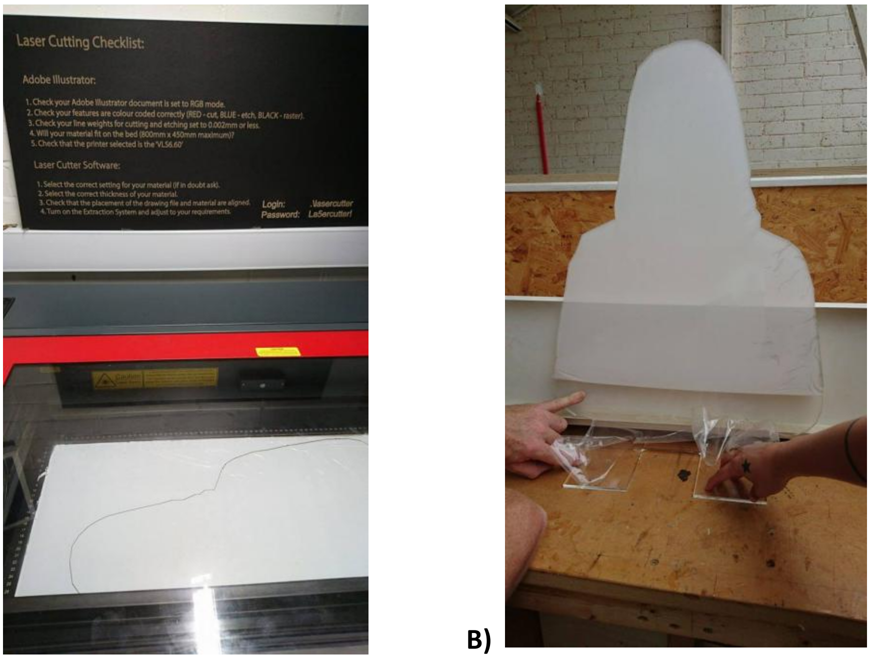
Figure 2.12. Confirmation of route presentation of the prototype of the holographic-like video counsellor.

With a reasonable result, we decided to employ this methodology in Study 4. Linda Solbrig, a PhD researcher who also is a trained actor and had been working on delivering MI and FIT in face-to-face interventions, became a collaborator for the development of the video for the holographic projection. The recording required performance skills so the coach would be able to keep posture and hands held still and no head movement but still seeming relaxed and empathetic.

We utilized a reduced version of the FIT script developed in my secondment at Queensland University of Technology. This compressed FIT script contained mental imagery exercises only and was not a dynamic interview. The intention was to substitute the dialogue to a 'listening video' with mental imagery responses to tackle the impersonal interaction. The 'listening video' presented a series of challenges as for how long the section needed to be to accommodate participants' answers and programming the video to be in loop in case the answers extended or how expressive the coach should be to show empathy but without contradicting participants' replies (e.g., smiling when the participant would be telling something sad). FIT offered a potential benefit in posing fewer challenges to the naturalness of the interaction. The FIT script conception is described in detail on Chapter 6. After several rehearsals and takes to achieve the desired delivery, the final video had a total of 13 minutes and 26 seconds captured in one shot using a teleprompter (Figure 2.13).

Figure 2.13. Studio recording of the reduced FIT script for the holographic projection using a teleprompter and green screen technique.

I developed the final shape outline in 5mm clear acrylic (Figure 2.14) using the same process described previously. For the base, the acrylic had to be partially melted to become malleable and forced to an angle of 90 degrees until it was dried and stable.



A) B)

Figure 2.14. A: Laser cutting machine after action. B: Moulding the base in 90 degrees from the silhouette.

For the projected video, I fixed the video’s alignment in Adobe Premiere as there were some slight movements of the counsellor, whose projection would deviate from the silhouette frame. To do this, I kept a central reference and adapted the whole video into that main point. Utilizing Adobe After Effects as previously described, I replaced the green screen by a solid black so the image of the counsellor would be the only element projected into the acrylic shape (Figure 2.15).

Figure 2.15. Frame from the video recording with a black background for projection in the acrylic shape.

For the final projection, we placed the acrylic cut-out on a central table in a room referred as a soft lab which is set up as a living room. We utilized an Epson EB-U04 projector placed in another table in the opposite side of the room for reproducing the video while the participant was sitting in an armchair, facing the holographic projection (Figure 2.16) (see a weblink in Appendix 2.6 with a sample of the FIT video for 2D projection).

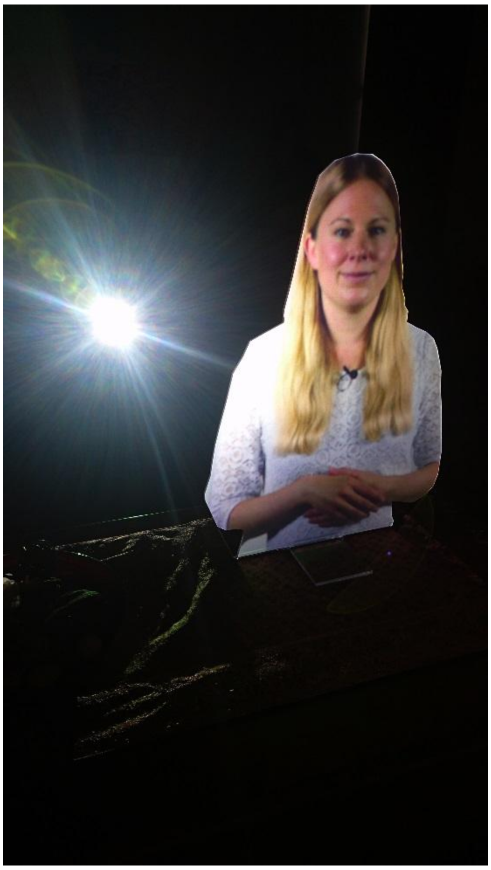


Figure 2.16. Holographic projection from a projector to the acrylic device.

Summary

In this chapter, I have depicted the conception and technical development of the different devices used in this project. I have described the various problem solving techniques that were needed, and given instructions to make all the four studies in this thesis reproducible. The technical development of each type of technology tried to incorporate the essence of MI and FIT in simple interactive designs. This project took considerable technical work to make these artificial coaches as lifelike and engaging as possible. We suspect that this is important for maintaining the illusion of interactivity. The empirical chapters report the extent to which we succeeded in developing acceptable virtual motivational coaches.

Chapter 3: Study 1 - Say it aloud: Change talk during a spoken, automated motivational interview delivered by video counsellor, and participants' perceptions after one week

Introduction

Motivational Interviewing (MI) (William R. Miller & Rollnick, 2012) is a widely used brief intervention to support motivation (Lundahl, Kunz, Brownell, Tollefson, & Burke, 2010; Rubak, Sandbæk, Lauritzen, & Christensen, 2005). It is a person-centred counselling technique, where the interviewer collaborates with the interviewee to elicit their own motivations and confidence for change, using reflective listening to amplify their emotional impact. MI is effective for behaviour change in a range of domains (Burke et al., 2003), including managing weight (Armstrong et al., 2011), reducing alcohol (Vasilaki, Hosier, & Cox, 2006), and increasing physical activity (O'Halloran et al., 2014). Many people who might benefit from motivational support are unable to access it (Booth, Prevost, & Gulliford, 2015). If MI could be automated and delivered remotely, it could help motivate the behaviour changes needed to reduce so-called lifestyle diseases such as diabetes and heart disease. We report the development and initial user testing of an automated motivational interview delivered via computer that, for the first time, encourages the participant to engage in an out-loud 'dialogue' with a pre-recorded video counsellor.

It might be argued that face-to-face or at least 'live' interactions are essential for delivering the empathetic, responsive, person-centred counselling that is the heart of MI, but in fact it has been translated into virtual delivery with some success. Shingleton and Palfai (2016) systematically reviewed technology-delivered adaptations of MI (TAMIs) for health-related behaviours. Thirty-two studies delivered fully-automated motivational interviewing interventions with no therapist/expert interaction, using emoticons, virtual 'buddies', or talking narrators to simulate discourse with a therapist. Although most of the studies only included a subset of MI features, TAMIs did help change behaviour.

Several studies have employed video clips in their TAMIs but often only to provide an introduction or education (e.g., Ahmedani et al., 2015; Alemagno et al., 2009; Budney et al., 2011; Friederichs et al., 2014; Osilla et al., 2012; Wagener et al., 2012). Gerbert and colleagues (2003) developed a more interactive Video Doctor system using branching logic and a library of video clips to create a tailored interaction. The Video Doctor asks questions and the client replies by choosing from answers shown on the screen. Their choice determines the program’s selection of the next video clip. Results have been encouraging. In a large trial of HIV-positive patients, Gilbert et al. (2008), found that the Video Doctor reduced illicit drug use and unprotected sex. A randomised controlled trial with pregnant women showed a reduction in cigarettes smoked per day for smokers who completed the Video Doctor program ($p = .05$) (Tsoh et al., 2010); effects on abstinence were promising but not statistically significant, probably because this part of the larger Health in Pregnancy trial was underpowered. Another sub-study from the same trial showed improvements in diet and exercise in the Video Doctor condition, though no impact on weight (Jackson et al., 2011). Humphreys, Tsoh, Kohn, & Gerbert (2011) showed that the Video

Doctor led to more women to have discussions with the healthcare provider about partner violence.

The Video Doctor program shows the potential to deliver an automated version of MI that impacts behaviour and may have benefits over traditional counselling for encouraging participants to discuss sensitive personal issues (Gerbert et al., 1999). However, outcome data on smoking and weight from the Health in Pregnancy subtrials suggest there is still room for improvement. Key to this improvement might be getting the participant to engage more actively in the MI.

Although previous TAMIs have used avatars to talk to the client, they have generally not required the client to talk back. A key principle in MI is that an individual's motivation will strengthen when they hear themselves articulating their goals, reasons and plans for change. An important aim is to elicit 'change talk', to increase the extent to which the client expresses a need or desire to change, relative to the extent to which they discuss reasons for maintaining their current behaviour ('sustain talk') (Apodaca & Longabaugh, 2009; Magill et al., 2014; Gaume et al., 2016). A recent review found that clients' change talk mediates the impact of MI therapists on health behavioural outcomes (Copeland et al., 2015). The current study tested whether change talk could be elicited during an automated motivational interview that used video interactive technology to encourage participants to communicate verbally with a video counsellor, mimicking a synchronous interaction within the limitations of current technology.

To our knowledge, only two studies have attempted to get participants to talk to the technology delivering the motivational interview. Kanaoka and Mutlu (2015) encouraged participants to speak to a robot acting as a motivational interviewer. They found that problems in speech recognition and gesturing that disrupted participants' illusion of dialogue and there was no benefit of the TAMI. Kahler, Lechner, MacGlashan, Wray, and Littman (2017) asked participants to speak to a computer whose responses were selected by a human operator in a Wizard of Oz scenario. They found benefits for this speech-based intervention compared to a text-based intervention for reducing alcohol consumption. These findings are consistent with our assumption that speaking aloud to a computer can bring benefits, but that speech recognition software is not yet sufficiently sophisticated to accommodate unconstrained responses by the speaker.

To allow participants to speak freely about their goals and concerns, we developed a single MI script where questions appeared in a fixed order rather than using Gerbert et al.'s branching logic. The goal was to provoke the participant to reflect, elaborate, and speak his or her answers to the virtual counsellor. In effect, we were encouraging a conversation with oneself through a virtual medium, which is the video counsellor. We assessed the interview by testing the extent to which it elicited change talk from participants. We hypothesized that participants would find it motivating to articulate and hear their own incentives and plans for change. We used qualitative methods to test this hypothesis and to explore participants' experiences of using the video-counsellor software, because apps that are too complex or hard to use can sap motivation rather than boost it (Solbrig et al., 2017). For ease of recruitment, we focused on motivation to increase physical activity because inactivity is a widespread problem, with only 6% of men and 4% of women in the UK achieving the government's recommendations regarding physical activity (HSE, 2008).

Methods

Materials

Motivational interviewing script

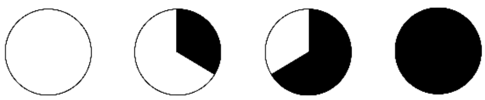
An intervention script was developed, based on manuals developed for face-to-face motivational interviews in clinical trials (Kavanagh et al., 2016; Solbrig & Andrade, 2016) and using Miller and Rollnick's (2002; 2012) books as guides. Care was taken that each question should make sense, regardless of the participant's answer to the preceding question. We iteratively read through the script and role-played different answers to see which follow-up responses by the video interviewer might work, modifying the script where possible to solve anticipated problems.

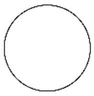
We shaped participants' expectations by advising them, at the start of the interview, that 'During this interview, sometimes I may ask you questions that you think you've already answered. If that happens, I suggest you use it as an opportunity to think about the issue a bit more'. We considered questions based on advantages of change and disadvantages of the status quo, optimism about change, intention to change, evocation, hypothetical change, setting goals, and arriving at a plan. The script asked permission to discuss behaviour change, and then developed discrepancy by asking about benefits of change and what may happen in the future if there is no change. There was a focus on feelings and concerns about possible futures, to evoke participants’ ideas and values, and to strengthen commitment to change (e.g., 'Why is that important to you now?'). Self-efficacy was promoted by asking about past successes and exploring how they could be applied to the current situation, eliciting awareness of increased confidence using 0-100 self-report ratings.

Questions throughout the interview were open-ended ('How does it make you feel?') and used collaborative language (e.g., 'So, is it okay if we talk about that now?'). The session ended with the video counsellor asking the participant to 'summarise what you are going to do, why you want to do it, and what makes you confident you can at least do it for a week'.

Full characterisation of the script, using Shingleton and Palfai’s (2016) schema for rating technology-assisted motivational interviewing, is shown in Table 3.1. Note that the standard instrument for assessing MI quality, the Motivational Interviewing Treatment Integrity scale or MITI (Moyers, Manuel, & Ernst, 2014), is not applicable here because it rates the interviewer’s behaviour in relation to that of the interviewee. The full script is provided in Appendix 3.1.

Table 3.1. Characterisation of video counsellor motivational interview using Shingleton and Palfai’s (Shingleton & Palfai, 2016) [9] schema (3 = good quality, as in face-to-face MI; 2 = pretty good but not optimal; 1 = present but superficial or inadequate; 0 = not present at all).

Quality of MI comprehensives in the TAMI	**Ratings**  **0 1 2 3**	**Comments**
Develop discrepancy/ explore ambivalence		Explores positives from change and elicits related feeling, but does

		not give an opportunity to explore sustaining factors, or consider their relative importance in comparison with advantages of change. It does not explore discrepancy from important values. It could have been done better by linking with core values.
Roll with resistance		Not possible in this format without branching.
Promote autonomy		It assumes the person will move to a goal – e.g. after consideration of advantages of change. No autonomy statements included. It gives choice in which goal and steps they select but does not reinforce that it is there choice to change or stick with behaviour. The interview is somewhat therapist-centred. “Give it a go” at the end of the self-efficacy section may elicit resistance.
Express empathy		Counsellor was selected on basis of seeming empathetic, and the listening part is intended to be

		perceived as empathetic.
Collaboration	◕	Some present but could be stronger, e.g., “It is okay if we talk about that now?”, “Let’s do this…”
Evocation	●	Strong, e.g., “Why is it important to you?”, “Does that worry or concern you. Why?”
Promote self-efficacy	●	Addressed well, e.g., “Let’s focus on your confidence in getting started. How confident are you that you can carry out this plan for the next week? Give it a rating from 0, not at all confident, to 100%, really confident.”
Strengthen commitment to change	●	Elicited by getting the participant to articulate/summarise a plan. E.g., “What will you do?” Language about plan gradually becomes more concrete.
Ask permission	◔	Only at start – poor that we are pushing towards a goal.
Reflections/summaries	◕	Video counsellor cannot reflect but elicits summaries twice. “I suggest you summarise what you are going to do, why you want to do it, and what makes you confident you can

		at least do it for a week”
Open ended questions	●	Strong on this.
Structure adapted to readiness to change/interest/self -efficacy	○	Not possible without branching in the interview script.
Other MI adherent behaviours (e.g., affirmations)	◔	Generally, not possible. “Looks like a plan”, is an example but generally affirmation is risky if used without knowing what participant has said. Amplification of emotion – “how does that make you feel?”

Video counsellor technology

The MI script was presented by an actor chosen in pilot work from five potential video-counsellors. The actor delivered the script using a teleprompter. She was asked to present a neutral facial expression with a warm and empathetic tone. A 7-minute 'listening video' was also shot with the actor looking directly at the camera, smiling slightly and nodding occasionally to simulate that she was paying attention to the participant’s answers.

Recording took place in a video studio with a green chroma key. In post-production, the green background was substituted by a neutral grey backdrop and an artificial orange-tinted light was added for a warmer atmosphere (Figure 3.1).

The recording was segmented and presented via computer as a Skype-style interaction where the participant viewed themselves in the computer's webcam as well as the video-counsellor (Figure 3.2). Each question was followed by the 'listening video', which played in a loop until the participant pressed a key to move on.

Figure 3.1. A: raw video with chroma key and original light. B: video with the original light and grey replacement background. C: video with grey background and light adjustment.

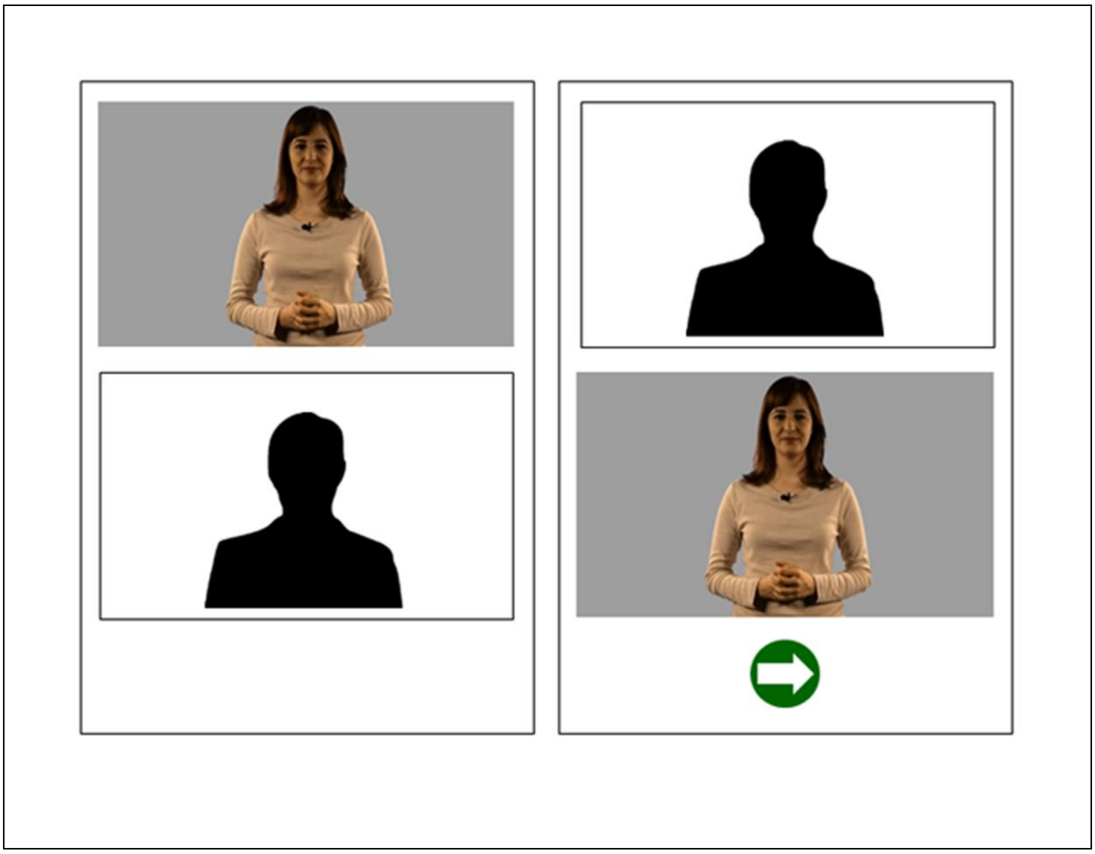


Figure 3.2. Design for virtual interview. The video counsellor asks a question while the participant is seen live on the webcam in the frame below (left-hand picture). The participant is cued to respond by the webcam frame moving to the higher position, with the video counsellor 'listening' in the lower frame. The participant clicks on the arrow to advance to the next question.

Evaluative questionnaire

An online questionnaire contained 24 open-ended questions covering the interaction with the video coach (e.g., 'How was your experience during the video interview?'; 'How connected did you feel with the video coach?'), self-perception during the interview (e.g., 'How did you feel about watching yourself answering the questions?'; 'How important do you think it was listening to yourself out loud discussing your behaviour?'), navigability (e.g., 'How did you find the interface?'), motivation for change (e.g., 'Did this video interview affect your motivation?'), engagement in physical activity after the program, and suggestions and criticisms about the program (e.g., 'What's the best (worst) aspect of this interview for you?'). Questions also covered general aspects of motivation to elicit ideas that could be incorporated into future developments.

Participants

A total of 18 participants (6 male, 12 female; >18 years) were recruited from the School of Psychology's pool of volunteers with a request for participants wishing to increase their physical activity levels. Participants received an honorarium of £8 per hour for taking part.

Procedure

The study was approved by the university's Faculty of Health and Human Sciences ethics committee. Participants visited the laboratory twice during July 2015: once for the video interview and again one week later to evaluate the intervention having had time to reflect upon its impact. In session I, participants answered the video coach's questions aloud in a simulated virtual conversation (Figure 3.3). Their responses were video and audio-recorded. In session II, they completed the evaluation questionnaire online.

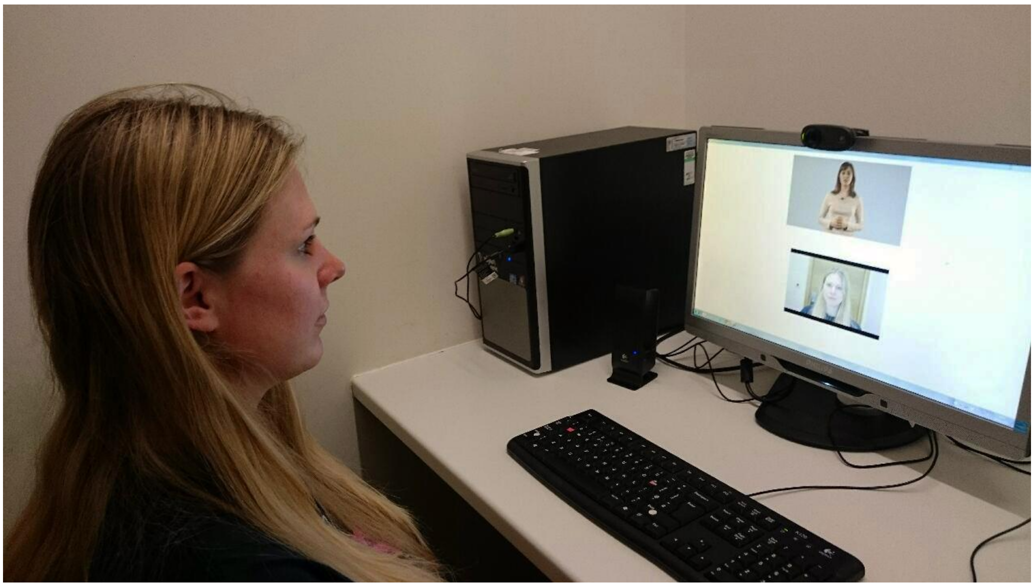


Figure 3.3. Simulation of the interaction between a participant and the video coach in the lab.

Coding of participants' speech

Participants' responses were rated for the total number of instances of change talk (arguments towards the target behaviour) and sustain talk (arguments against the behaviour or for the status quo) (Miller & Rollnick, 2012) using the Client Behaviour Codes section (p.37 onwards) of the Motivational Interviewing Skill Code (MISC 2.5) (Houck, Moyers, Miller, Glynn, & Hallgren, 2010). Coding was performed by the first author (JGGdS) using a coding sheet based on the MISC 2.5 (see Appendix 3.2). Three participants' recordings were also rated by the second author (JA), who is trained in MI, and points of disagreement were resolved through discussion before coding the remaining interviews. Specific decisions made through this discussion were:

- To code ideas for change as Commit statements when they followed a question like 'are there any strategies you could apply over the next week?', even if they were phrased in the third person (e.g., *Yes, you have to set aside a time*).
- To code related ideas as one instance, for example, *I would feel better, healthier* (one Reason) or *I could go running before work, or in the evenings* (one Commit statement).
- To code ideas that were conceptually different as more than one instance, for example, *I would feel fitter and my race times would get better* (two Reasons) or *I could go running or start swimming again* (two Commit statements).

Thematic Content Analysis

Thematic analysis was used to identify and code patterns, or themes, in participants' evaluations of the video interview. We used the three-step method recommended by Boyatzis (1998): (1) sampling and design, (2) developing themes and codes, and (3) validating and using the codes.

(1) Sampling: There were 18 potential units of analysis, one set from each participant.

(2) Coding scheme: Themes and sub-themes were developed with a hierarchical relationship. The codes were developed according to Boyatzis' steps by generating a coding scheme through immersive reading of the units of analysis, then reviewing and revising categories and sub-categories iteratively.

(3) The resulting code was validated by two independent coders who each applied the coding scheme to the responses of two randomly-selected

participants, rating each category or sub-category as 'mentioned' or 'not mentioned' by the participant.

Results

Analyses are based on responses from 16 of 18 participants (4 male, 12 female). Data from two participants were excluded: one did not understand that the interview was about physical activity and the other made jokes and flippant remarks throughout the interview.

Change and sustain talk

The interview lasted a mean of 10min 50sec (SD 3min 01sec). There was considerably more change talk than sustain talk (Figure 3.4), with a mean of 30.7 instances of change talk (SD = 13.3, range 15 to 66) compared with a mean of 4.1 instances of sustain talk (SD = 2.9, range 1 to 10). There were examples from all categories of change talk (table 3.2).

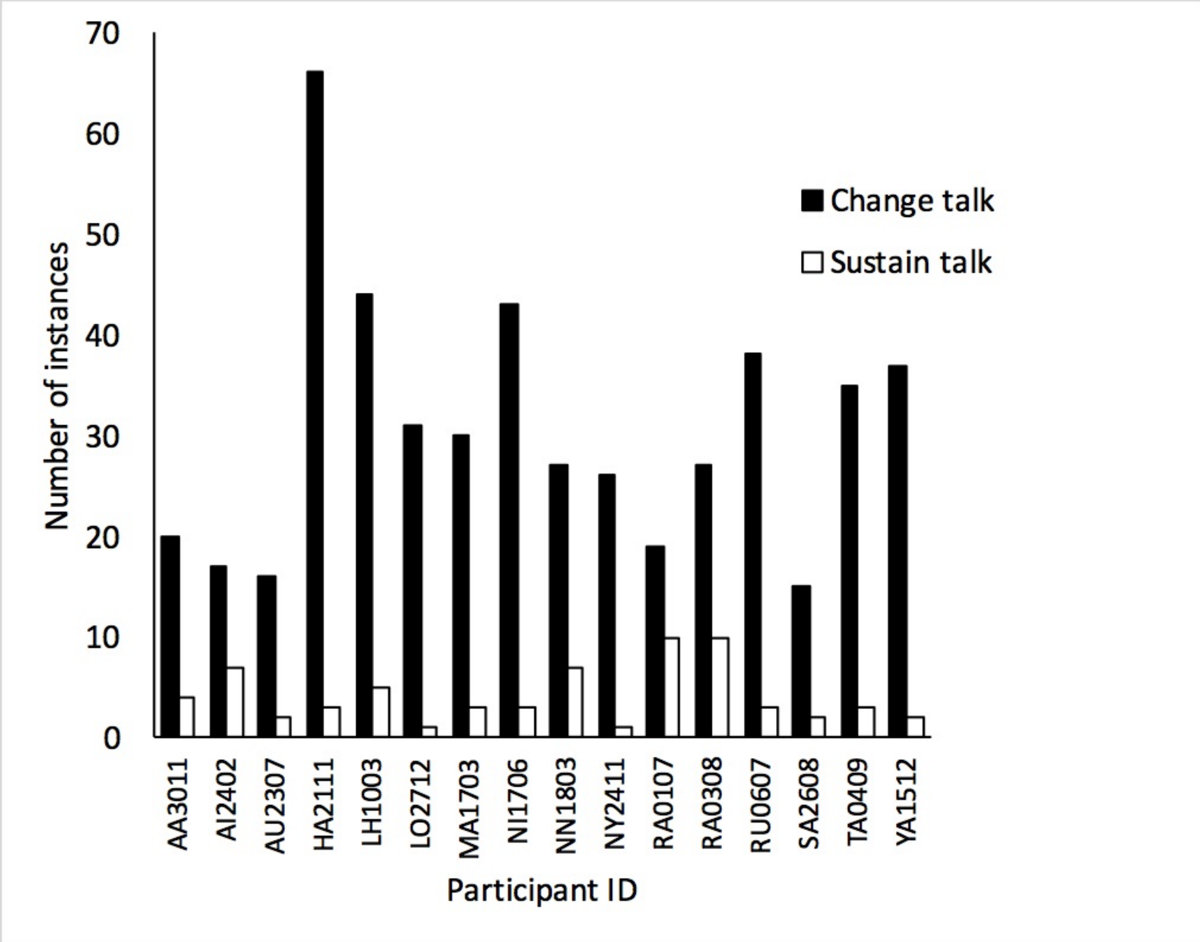


Figure 3.4. Instances of change talk and sustain talk during each interview with the video-counsellor.

Table 3.2. Examples of change and sustain talk elicited by the video-counsellor.

Category	Change talk	Sustain talk
Commit	*I've decided to do it and I'm going to do it.* *I will go to the Life Centre, it’s on the way home, and I will see when the sessions are that I could take part in.* *I could consider joining a water polo team.* *I'll start running again in the mornings, at least once or twice this week.* *I could increase the days I volunteer with the local animal charity and to walk a dog for*	*I should be able to do some physical exercises. But I'm really busy this week, I don't know if I'll have time to do it.* *I'm expecting to have to do some work that I'll have difficult to accomplish... that might take my focus and I'd get preoccupied with my main task and not with my fitness regime.* *It's just I got so much to do, I'm also very busy in the day time. I don't know how that's going to change.* *Over the next seven days I'm fully occupied with various things and*

	them.	*nothing will start in the next seven days.*
Desire	*I'd like to start doing [it] again.* *[If I don't change] I'll carry on being a couch potato and I don't want to do that.* *I want to improve my body postures.*	*I'm usually quite tired after work, and not really wanting to do anything.* *Well, I've got some sports on the television coming up which is time consuming sitting watching that, and I wouldn't want to miss it.*
Ability	*I definitely think I'm capable of it.* *I have more time now and inclination to actually try.* *I think I'm confident I'm able to start this mainly as it's something I really want to do. I know that I've succeeded in the past, so I can do it again.* *That plan I reckon I'm confident to about a 8.*	*I don't know if I'll have time.* *[The] difficult thing would be maintaining it in the autumn.* *I'm very busy in the daytime… I can't see how that's going to change.* *Well, not sure if I can actually do it, maybe I need more support with that.* *I have very little confidence that I can get started because I'm so busy all the time.*
Reason	*Hopefully it will improve my fitness.* *I'd like to be a stronger member of the team.* *I'd like to be as fit as possible now so that later on in life I have a better chance of good health.* *Just because of the family history of heart problems and stroke. My dad had a stroke and he was unfit. So I see what it leads to.*	*On Tuesday I'm going to go to a friend's house for the evening and on Friday next week I got a friend coming around to mine's so that might make me not want to do anything.* *Trying to get running in the mornings, after a long day of data collection is difficult.*
Need	*I need to do more exercise to feel healthier.* *I need to do more running.* *I need to get more exercise than I currently have.*	*I don't think it's too much of a worry because of what I already do.* *It wouldn't be disastrous if I didn't.*
Taking Steps	*I've been looking at fitness programs I can get into.* *I've actually just been on holiday again and I've done two days of hard walking.*	*I seem to be spending a lot of time sitting when I should be out in fresh air.* *A lot of my time it's spent sitting, working at the computer, and I don't give myself enough breaks so it's just going to go from bad to worse.*

Other	*Running first thing in the morning helps motivate me.* *There are real benefits partaking in extra sport.*	*It's about commitment and regularity and, having changed lifestyles and retired, that commitment and regularity isn't there.*

Qualitative Video Counsellor Evaluation

Table 3.3. Coding scheme.

Hierarchy	Themes and sub-themes
1	**Video coach intervention**
1.1	**Program evaluation**
1.1.1	**Coach**
1.1.1.1	Positive
1.1.1.2	Negative
1.1.2	**Interaction**
1.1.2.1	Emotional reaction
1.1.2.1.1	Positive
1.1.2.1.2	Negative
1.1.2.1.3	Virtual system
1.1.2.2	Realistic
1.1.2.2.1	Not realistic
1.1.2.2.2	Restricted
1.1.3	**Script**
1.1.3.1	Positive
1.1.3.2	Negative
1.1.4	**Interface**
1.1.4.1	Instructions
1.1.4.2	Navigation
1.2	**Personal experience**
1.2.1	**Self-image on the webcam**
1.2.1.1	Positive
1.2.1.2	Neutral
1.2.1.3	Negative
1.2.2	**Motivation**
1.2.2.1	Secondary strategies
1.2.2.2	Challenges
1.2.2.3	**Engagement in physical activity after the program**
1.2.3	Didn't increase exercise
1.2.3.1	Planned and executed activities, increased exercise, and/or intensity
1.2.3.2	**Overall evaluation**
1.2.4	Suggestions
1.2.4.1	Positive appraisal

Reliability Test

The interrrater reliabilities for the two units (NY2411 and NN1803) were 90.41% and 80.82% respectively. Raters discussed divergences, and subcategories were adapted accordingly.

Participants' Evaluation

Theme 1: Program evaluation (1.1)

Coach (1.1.1)

Some participants felt empathy towards the coach while others found the lack of individualised response frustrating.

> *I felt moderately connected [with the video coach], far more than filling out a survey but not as much as if the person had been an actual person rather than a virtual person. (YA1512)*

> *I felt like the interviewer was talking to me personally even though I knew it was a recording. (TA0409)*

Interaction (1.1.2)

The pre-recorded questions made the interview less fluid than one would expect in a face-to-face interaction. Most of the participants noticed that the questions were impersonal but could overcome this barrier and experience something that felt like a conversation.

It was engaging, not as much as if the person had been real and been relational but it was useful and relatively engaging once I got over how surreal it felt for the first couple of questions. (YA1512)

Script (1.1.3)

There were mixed reactions to the necessarily generic questions.

The questions were clear and understandable. I did feel like I was repeating myself sometimes but I probably should have elaborated a bit more at those times. (TA0409)

… not always clear, it was vague, and some more details would've been nice. (LO2712)

Interface (1.1.4)

Participants found the interface straightforward.

… very easy to use. (TA0409)

Theme 2: Personal experience (1.2)

The personal experience theme covered participants' experiences of using the virtual intervention, their strategies for motivating themselves, and their reflections on their behavior in the week after the intervention.

Self-image on the webcam (1.2.1)

We anticipated that participants would find the webcam interface familiar and comfortable, but most had a negative reaction:

> *[Watching myself on the webcam] took focus away from dialogue and interaction, [I] found myself looking at my body language. (AA3011)*

> *I felt quite uncomfortable and it was hard to look at the camera, I felt that I had to look down most of the time. I felt like I was having the pressure put on me. (RA01007)*

Listening to oneself (1.2.2)

Participants were positive about hearing themselves express their thoughts aloud, feeling that it helped the process of thinking about their behaviour and setting goals for the future. They gave a sense that speaking aloud made the issues feel more real: more urgent but also more achievable.

> *[Listening to myself out loud] was very important. It helped me to better realise my shortcomings and to come up with new potential solutions. (NI1706)*

> *[It] made me own the reality of my exercise habits which is otherwise easy for me to avoid. (YA1512)*

Motivation (1.2.3)

Participants used a wide range of strategies to motivate themselves. Some strategies could be incorporated into a virtual intervention, for example reporting back on progress to the video-counsellor, but participants did not spontaneously make links between the video interview and their personal strategies.

> *[I tried other motivation techniques before]: affirmations and motivation meditation. (NY2411)*

> *[What helps me the most in staying motivated is] having to report back on my progress at a later date. (RN1703)*

> *… enjoying the activity and having some flexibility when I can do it. (RU0607)*

Participants mentioned a range of challenges that prevented them from achieving their goals. None spontaneously commented on whether the interview had helped them overcome these challenges.

> *… laziness - always having something else I'd rather do, even though I know I will feel happy once I've done the exercise. (HA2411)*

Engagement in physical activity after the program (1.2.4)

Most of the participants engaged in physical activities in the week after the interview. The intervention prompted a quick planning reaction from some participants who immediately booked gym classes.

> *I booked all my gym classes in a week before … (YA1512)*

> *I started daily exercises, but not swimming like I thought about. (AI2402)*

Overall evaluation (1.2.5)

Participants suggested several improvements to the program.

> *… removing the video component and having an option to seek clarification or replay a question. (YA1512)*

> *… if she sat down and spoke it bit slower. (TA0409)*

> *…providing a way of listening back to yourself to see if you have met your goals. (LH1003)*

Participants said they valued the program because it offered an opportunity to think about the issues and voice their goals. They found it thought provoking. It helped them to make plans and strengthened their sense of responsibility for their own behaviour.

> *[The best aspect of this video interview was] the fact that I could voice my goals, and see the person voicing their goals – me – and*

realise that it was a person saying these things not just mere words. (LO2712)

… reinforcing the pleasure I get from exercise. (AA3001)

… it made me focus and to clearly articulate the problems, the motivations, and the potential ways to overcome these. (NI1706)

Discussion

We tested a virtual motivational interview that engages participants in a 'conversation' where they speak aloud to a pre-recorded interviewer. Unlike other technology-assisted motivational interventions (TAMIs) that use video to introduce text-based interventions, our intervention required a spoken response from the participant and 'listened' to their answer. Participants found the interface easy to use but disliked seeing their own image in the live webcam projection. Although they would have liked a more personalised, tailored interaction, they still felt moderately engaged in the interview. They found listening to themselves verbalizing their goals and motivations for change to be important and effective, as predicted by self-perception theory (Bem, 1972). This is the most novel aspect of the intervention and the one that elicited the most positive evaluations.

Quantitative ratings of participants' speech showed many examples of 'change talk' and some examples of 'sustain talk'. In that respect, the TAMI achieved a key aim of a motivational interview, which is to elicit change talk. It did this through MI-consistent behaviours such as asking open questions and eliciting summaries (Table 3.1). Studies of the mechanisms of MI show more change talk when therapists use more MI-consistent skills (Apodaca et al., 2016; Magill et al., 2014; Moyers et al., 2007; Romano & Peters, 2016). Change talk is generally positively associated with outcomes (Apodaca et al., 2016; Moyers et al., 2007; Romano & Peters, 2016; but not Magill et al., 2014). These studies also found that MI-inconsistent behaviours, for example, giving unsolicited advice, were associated with more sustain talk and poorer outcomes. Our video-counsellor had one advantage over a live human interaction: there was no scope for those MI-inconsistent behaviours that are associated with poorer outcomes.

The relative simplicity of the video-counsellor interview may have weakened its impact. There is evidence to suggest that the most effective MI is one that encourages deep, emotionally charged, exploration of discrepancy. Magill et al. (2014) found some evidence that complex talk about change, where participants discuss positive and negative aspects together, might be the critical predictor of outcome. Similarly, Apodaca and Longabaugh (2009) found a positive association between outcomes and clients' experience of discrepancy. Although our interview elicited plenty of change talk and some sustain talk, we assume that a live interaction, which used reflection to magnify participants' incentives and conflicts, would have strengthened motivation further.

Another limitation with a TAMI is that it cannot, yet, express empathy in relation to the individual's specific utterances. Relational qualities such as empathy have positive effects on the client's within-session collaboration and engagement (Moyers, Miller, & Hendrickson, 2005) and possibly on outcomes (Gaume, Gmel, Faouzi, & Daeppen, 2009). However, Romano and Peters (2016) did not find a clear association between relational variables and change talk or behavioural outcomes. Future research should test whether a TAMI that encourages change talk, as ours did, has a positive impact on behavioural outcomes even though it lacks some of the positive relational qualities of a live person-to-person interview. The question is not whether a TAMI is as effective as a conventional MI, but whether it can provide some benefit for people who do not have access to a therapist.

There is a tension between developing virtual interventions that feel personalised because they follow a logic tree specific to a particular context, and developing a general-purpose intervention. Our TAMI was developed for this second purpose, allowing participants to talk about whatever they chose, and in that respect was true to the spirit of MI. Without sophisticated speech recognition software or a live counsellor, it is hard to adhere to elements of MI such as reflection, but our interaction did include many important elements of MI including eliciting the participants' own values, goals and reasons for change. Participants felt they benefited from talking about change, even to a virtual interviewer asking generic questions, reinforcing the core tenet of MI that it is what the client says that is important, not what the interviewer says to evoke it.

Next steps are to test if the virtual counsellor motivates behaviour change, and to test whether people seeking motivational support will engage spontaneously and repeatedly with the intervention in real-world settings. If these conditions are met, then our study is a step towards delivering a fully automated motivational interview that is cheap, effective and widely accessible.

Practice implications

The interactions described here fall far short of a face-to-face interview. Nonetheless, they show that virtual interventions can help people start talking about their goals, potentially increasing access to motivational support and preparing people for face-to-face counselling. Previous eHealth programs have been criticised for lacking human therapist involvement, leading participants to feel disengaged (Darvell, Kavanagh, & Connolly, 2015). A video-counsellor could help provide some sense of human contact and engagement.

Chapter 4: Study 2 - Experiences of a motivational interview delivered by a robot: A qualitative study

Study 2 followed on from Study 1, having an identical study design with a qualitative evaluation one week after the intervention. Study 2 was published in the Journal of Medical Internet Research in May 2018. Below is the published version in which its methods overlap with Study 1. We used a similar MI script developed for Study 1 with slight differences, but now delivered by a robot. While in Study 1, the script was generalised for any behaviour and we gave instructions to participants to answer the questions regarding physical activity, in Study 2, we changed the questions so they explicitly asked about physical activity levels. For instance, in Study 1, the script stated, 'Try summarising the things that are likely to get better if you'd change your behaviour', while in Study 2, 'Try summarising the things that would change for the better if you'd become more active.' We also altered some of the words for better diction by the robot. The set of qualitative questions changed slightly. For instance, in Study 1, the question was 'How did you feel about watching yourself answering the questions?' as there was a webcam, in Study 2, the question was changed to 'How did you feel about hearing yourself talk about your goals out loud?'. The thematic analysis followed the same approach as in Study 1.

Introduction

Lifestyle factors such as physical inactivity impose a considerable burden on society's healthcare resources and individuals' well-being (HSE, 2008). Participants in qualitative studies focusing on weight management say they want motivational support to make lifestyle changes (Hardcastle & Hagger, 2011;

Solbrig et al., 2017) but public health budgets constrain societies' ability to offer face-to-face counselling (European Commission, 2012b). Social robots that can deliver effective motivational support could offer a way to increase access and encourage behaviour change. This paper reports a study of participants' experiences of a robot-delivered motivational interview to support their goal of becoming more physically active.

Motivational interviewing (MI) (William R. Miller & Rollnick, 2012) is one of the most effective psychological interventions for supporting behaviour change (Rubak et al., 2005; Lundahl et al., 2010), including for increasing physical activity (Bennett, Lyons, Winters-Stone, Nail, & Scherer, 2007; Hardcastle, Taylor, Bailey, & Castle, 2008). The MI practitioner uses a person-centred counselling style to engage the client in discussion of their current problem and to elicit their own ideas for solutions. This collaborative stance is considered important, because people are likely to react to directive, advice-giving, ('doctor-patient') counselling styles by trying to justify their current behaviour, and voicing these justifications may strengthen their resistance to change (Miller, Benefield, & Tonigan, 1993; Patterson & Forgatch, 1985). The aim of MI is to encourage the client to voice their own arguments for change, as hearing oneself arguing for change increases belief that change is important and will happen (Bem, 1972). Given the focus on personalised dialogue, MI delivered by robot might seem a distant dream.

Although people may have preconceptions about robots from science fiction films, few have had opportunities to interact with one. Two streams of development dominated early robotics: remote navigation for observing hard-to-reach environments, and manipulation for replacing human manual work in industries. Recently, there has been a new focus on humanoid robots as personal assistants or carers in daily life (Goeldner, Herstatt, & Tietze, 2015; Kanda & Ishiguro, 2017).

These 'social robots' have been used to provide educational support for children (Benitti, 2012) and assistance to elderly individuals (Broekens, Heerink, & Rosendal, 2009). They have proven acceptable and effective for helping children with type 1 diabetes to learn about their condition and how to manage it (Belpaeme et al., 2013) and are being trialled as therapeutic aids for children with Autism Spectrum Disorders, with results showing therapeutic outcomes similar to those of one-to-one therapy (Scassellati, Admoni, & Matarić, 2012; Thill, Pop, Belpaeme, Ziemke, & Vanderborght, 2012). Robots have also become personal trainers instructing and motivating the completion of exercises such as spinning, rowing, and bodyweights (Schneider, Goerlich, & Kummert, 2016) or engaging elderly users in physical exercises (Fasola & Matarić, 2012), as well as weight loss coaches stimulating tracking of calorie consumption and exercise and being twice as effective as a standalone computer or paper log (Kidd & Breazeal, 2008). However, naturalistic dialogue between robots and humans is currently limited by robots' speech processing capabilities and the capacity of artificial intelligence to cope with unconstrained input (Cantrell, Schermerhorn, & Scheutz, 2011). The use of robots for therapy has therefore been limited to education and engagement rather than delivery of interventions where dialogue is critical.

There have been attempts at mechanising delivery of motivational interviewing using text, audio, video, and animations, with some success (Shingleton & Palfai, 2016). For example, Jackson and colleagues used branching logic and a pre-recorded 'Video Doctor' to guide pregnant women through a motivational interview. Their trial showed improvements in diet and physical activity (Jackson et al., 2011) and reductions in smoking (Tsoh et al., 2010), although no clear effects on smoking abstinence and weight. There was also evidence that the Video Doctor led to more women discussing partner violence with their healthcare practitioner (Humphreys et al., 2011). Interfaces have generally relied on participants entering text or selecting pre-programmed options, making the intervention less person-centred than is ideal and removing the benefits central to MI of hearing oneself argue for change.

Social robots have the potential to engage participants in a motivational interview so they hear themselves argue for change. To our knowledge, only one other group has tested robots in this way. Kanaoka and Mutlu (2015) used a NAO robot to deliver a motivational interview. They found no benefit of MI compared to a traditional advice condition. They attributed the lack of benefit of MI to a lack of fluency in the dialogue between the robot and the participant, with errors in speech recognition and incongruous nonverbal behaviours destroying the illusion of a meaningful two-way conversation. A complete motivational interview, with personally tailored questions and reflections upon the client’s answers, still poses substantial challenges to robot speech recognition and artificial intelligence.

This paper reports the development and assessment of a simpler solution, using a social NAO robot to elicit change talk with a pre-programmed set of questions. In contrast to previous attempts to automate MI, apart from Kanaoka and Mutlu's study, the focus of the interview was on encouraging participants to talk to the robot about their motivation for change, using open questions designed to draw attention to the discrepancy between the participant's current behaviours and core values. Apodaca and Loganbaugh (2009) found that change talk and experience of discrepancy are the main mechanisms of change in MI. A pre-programmed set of questions falls short of the person-centred counselling style that is at the heart of MI. However, if this approach succeeds in encouraging participants to talk freely about their concerns and their plans, we contend that it would present a substantial step forward in the use of technology to deliver motivational support.

The aim of the study was to explore participants' experiences of talking to the robot in a dialogue based on MI but constrained by current technology. We specifically wanted to know how people felt about discussing their issues with the robot and whether they felt that the interview affected their motivation.

Methods

Materials

Motivational Interview script

We created an intervention script using manuals developed for face-to-face motivational interviews in clinical trials (Kavanagh et al., 2016; Solbrig & Andrade, 2016) and Miller and Rollnick's book *Motivational Interviewing: Preparing People for Change* (2002) for guidance. Each question needed to make sense, regardless of how the participant answered the question before. To anticipate potential glitches in the flow of the dialogue, we iteratively role-played potential responses to the questions and adjusted the script where necessary.

We shaped participants' expectations by advising them, at the start of the interview, that 'During this interview, sometimes I may ask you questions that you think you've already answered. If that happens, I suggest you use it as an opportunity to think about the issue a bit more'. The questions covered MI elements such as advantages and disadvantages of the status quo, optimism about change, intention to change, evocation of ideas about change, hypothetical change, setting goals, and arriving at a plan (Miller & Rollnick, 2002). As in MI, the interview moved from a general discussion of the pros and cons of change to development of specific plans for change. The questions were designed to encourage participants to articulate their ideas about change and to consider the discrepancy between their current behaviours and core values. In a real motivational interview, the interviewer uses reflection as a tool for amplifying emotions associated with the pros and cons of change, repeating, paraphrasing or elaborating salient statements made by the participant. Because this personalised reflection is not possible in a pre-scripted interview, we sought to amplify emotion using open questions to encourage the participant to think deeply about their incentives. For example, the robot asked: 'What may happen in the future if you don’t change anything?' followed by 'Does that worry or concern you?'. The script did not refer to any specific goals or behaviours, so that it could be generalised to many situations, but participants knew that the study was about increasing physical activity.

To help readers understand the strengths and weaknesses of the robot’s script, we characterised using Shingleton and Palfai’s (2016) schema for rating technology-delivered adaptations of MI, which was published after we developed the robot interview. Shingleton and Palfai scored features of MI as present or absent. To give a more accurate account, we rated the degree to which each quality of MI was present, from zero (absent) to three (completely addressed). We note that the standard tool for evaluating the quality of MI, the Motivational Interviewing Treatment Integrity manual (Moyers et al., 2014), is not applicable here because it is used for rating the interviewer’s interaction with the client.

Table 4.1. Characterisation of the robot-delivered motivational interview using Shingleton and Palfai’s [24] criteria for assessing technology-delivered adaptations of motivational interviewing. Scoring is as follows: 3 = component is fully present in interview; 2= present but not optimal; 1 = present but superficial or inadequate; 0 = absent. Examples are quoted in italics.

Ratings	**Quality of motivational interviewing components in interview delivered by NAO robot**
○ **0**	Roll with resistance Structure adapted to readiness to change/interest/self-efficacy Express empathy

1	Promote autonomy, ask permission: *Is it okay if we talk about this now?* Other MI adherent behaviours: *How does that make you feel?* (amplifying emotion)
2	Develop discrepancy/explore ambivalence: *What may happen in the future if you don't change anything?* Collaboration: *Let's focus on …* Reflections/summary: Summary was used – *I suggest you summarise what you are going to do…* – but reflection is not possible in a pre-scripted interview.
3	Evocation: *Why is that important to you now?* Promote self-efficacy: *What could you do, to make sure you follow your plan over the next week?* Strengthen commitment to change: *Try summarising the things that are likely to get better if you change your behaviour* Open ended questions: *What would be the first step?*

Programming the NAO robot

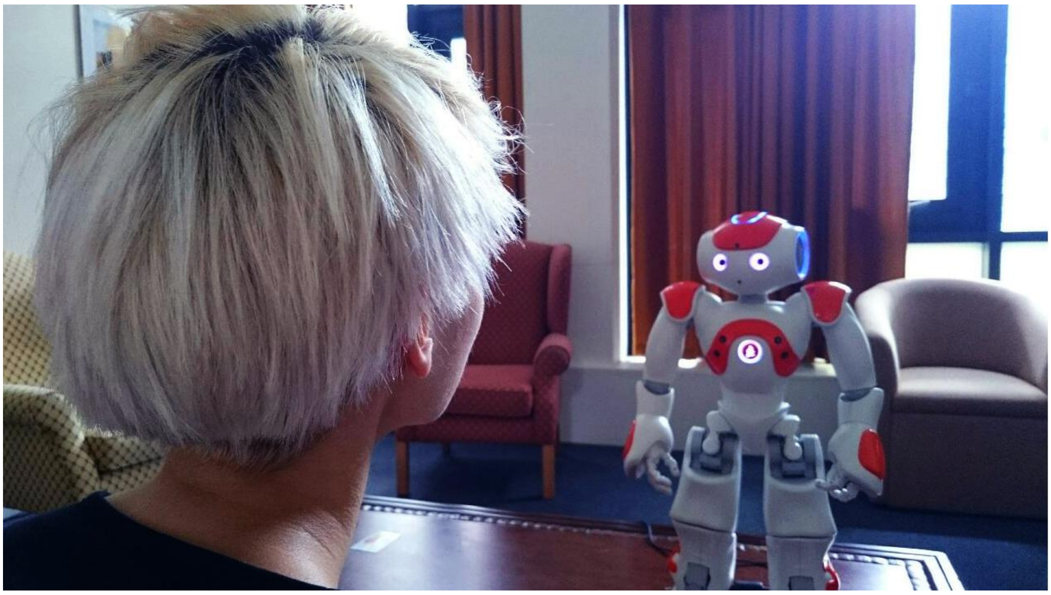


Figure 4.1. An illustration of the interaction between a participant and the NAO robot.

We used a NAO robot (Figure 4.1) to deliver this intervention. NAO is developed by Aldebaran Robotics with speech and movement capabilities. It is brightly coloured, 58cm tall, with large eyes and humanoid appearance. NAO was chosen for this intervention because of its user-friendly software package Choregraphe, and because it has been well received by participants in previous research (Baxter, Ashurst, Read, Kennedy, & Belpaeme, 2017). The robot was programmed with Choregraphe software, which is used to create behaviours, monitor, and control the NAO robot. The instructions were sent wirelessly to NAO so the experimenters were able to run the programmed script from a computer in a different room. The experimenters could monitor the progress of the interview visually, via a live camera in NAO's head.

Much of the programming effort was devoted to determining the intonation and speed of each sentence so the questions were easy to hear. The robot’s voice pitch was kept at the default from the manufacturer. A simpler approach would be to record a human asking the questions and have the robot replay the recording. We felt this option was not viable because it would destroy the illusion that the robot was asking the questions itself. In addition to programming the robot’s speech, we incorporated some ready-programmed modules that come with the Choregraphe software package, to give the robot a life-like, animated appearance. These modules included 'breathing', in which the robot sways gently emulating breathing and slight fidgeting, and eye colour. The robot’s eye colour changed from blue (question) to green (answer) to indicate whether the participant should listen or answer at each point in the interview. The face-tracking mode enabled the robot to follow the participant’s face, regardless of his or her movements during the interview, to give a sense that NAO was paying attention.

Setting

For the interview with the robot, we utilized a lab (Figure 4.1), styled as a living room, to create a relaxed atmosphere. The participant was left alone with the robot in this room.

Evaluative questionnaire

A questionnaire was developed to explore participants' experiences of their interview with the robot, and their impressions of its impact on their motivation. We used an anonymous, computerised questionnaire rather than a semi-structured interview because we wanted participants to feel as free as possible to give an honest account of their experiences and not feel socially pressured into praising the robot.

The questionnaire included 24 open questions. The questions were designed to address the primary aim of the study, to explore participants' experiences of a motivational interview delivered by social robot. To ensure that participants considered different aspects of the interview, questions asked about how they felt during the interview (e.g., 'How was your interaction with the robot?'; 'How engaging did you find the interview with the robot?'), how easy they found the robot to use and understand (e.g., 'How was your understanding of each question? Was the content clear?'; 'How did you find the robot's interface? Was it easy or difficult to use?'), how they felt about listening to themselves discussing their goals aloud (because this is a core component of MI), and whether they perceived an impact of the interview on their motivation ('Did this interview with the robot affect your motivation? How?'; 'Did you improve your physical activity after the robot interview? How?'). To encourage a balanced appraisal, two questions asked specifically what participants found the best, and worst, aspects of the intervention. The full questionnaire is provided in the Supplementary Materials (Appendix 4.2).

Participants

A total of 20 participants (17 female; 3 male) was recruited from the School of Psychology's pool of research volunteers. Participants were required to be aged 18 years or over and received £8 per hour to participate. Eleven participants were aged 18 – 25 years; four 26 -33 years; one 34-42 years; two 43-60 years; and two above 61 years).

The study advertisement asked for volunteers wishing to increase their physical activity. Participants were informed that they would take part in a physical activity intervention over two sessions, which included an interview with a robot. The study was approved by the University of Plymouth Faculty of Health and Human Sciences research ethics committee and informed consent was signed by participants, who were assured of anonymity and told they could withdraw at any point of the study as per British Psychological Society guidelines. They were told that the interview would take approximately 15 minutes and would not be recorded. Participants were advised not to take part in the study and to seek medical assessment if they had any concerns about their health or ability to exercise.

Procedure

The robotic intervention was comprised of two phases: lab session I and lab session II. There was a one-week interval between them, to allow time for participants to reflect on any impact of the interview while minimising forgetting and intervening variables.

In session I, participants answered the robot's question out loud in a simulated conversation with the robot with the participants touching the robot's head sensor to advance to the next question. As previously stated, NAO's eye colour changed from question to listening mode when it was the participant's turn to speak. Participants were not alerted to this feature, as we intended it as a subtle turn-taking cue. Interviews were not recorded, because participants in pilot work anticipated that they would feel uncomfortable talking to the robot as it was a novel experience, and would prefer not to be recorded. We return to this issue in the Discussion.

One week later, in lab session II, participants returned to the lab and evaluated the intervention through a computerised evaluative questionnaire with open-ended questions, and typed answers.

Thematic Content Analysis

Participants' answers to the evaluative questionnaire were content analyzed utilizing a three step methodology recommended by Boyatzis (1998): (1) sampling and design, (2) developing themes and codes, and (3) validating and applying the codes. The first step of the content analysis was to define the set of units of analysis to be investigated further. The full set of responses to the qualitative questionnaire from each participant was delineated as each unit of analysis. There was a total of 20 units of analysis, one set per participant. The coding scheme originated from the text itself, with the main and sub themes being developed based on Boyatzis' (1998) steps: (1) generating a code, (2) reviewing and revising the code, (3) determining the reliability of the code.

Immersive readings of the units of analysis led to the development of a series of potential codes. The text was further analysed and generated a set of themes and sub-themes based on common recurrent topics. Analysis continued until no new themes emerged.

Testing the reliability of the code

In validating the code, it is important to check that the coding scheme can be applied consistently. Boyatzis recommends having two independent coders rate a subsample separately, and computing the inter-rater reliability. We did this in two stages. First, two coders directly involved in the study (JGGdS and JA) rated two units of analysis independently. Differences in applying the code were discussed and the coding scheme was adjusted accordingly. Then, two new raters, with no involvement in the study, applied the adjusted coding scheme to five further randomly selected units of analysis by deciding if each item in the code was mentioned or not mentioned. Inter-rater reliability was computed as the percentage of items agreed upon for each unit of analysis.

Results

Thematic content analysis

Table 4.2 depicts the coding scheme developed with the themes and sub-themes identified. The coding scheme distinguished between experiences of interacting with the robot; participants' own strategies for and barriers to motivation; physical activity in the week following the intervention; and overall evaluation of the intervention which included suggestions for improvements. There was some similarity between the themes 'interview evaluation' and 'overall evaluation'. The ‘interview evaluation’ theme incorporated answers to most of the questions and covered specific feelings experienced during the interview, for example feeling relaxed, engaged, or self-conscious, and usability of the interface. The ‘overall evaluation’ theme covered impressions of the intervention as a whole, and suggestions for improvements, particularly but not solely covering responses to the questions about the best and worst aspects of the intervention. The theme on ‘motivation’ covered ideas that participants used spontaneously, whereas the ‘physical activity’ theme covered impressions of whether the interview affected motivation and activity in the week after the interview.

Table 4.2. Coding scheme.

Hierarchy	Themes and sub-themes
1	**Interview evaluation**
1.1	**Interaction/Connection with the robot**
1.1.1	Positive
1.1.1.1	Smooth connection, enjoyable experience, feeling relaxed, comfortable and/or cheerful
1.1.1.2	Engaging, interesting, fascinating and/or helpful
1.1.1.3	Better than talking to a real person and/or writing
1.1.1.4	Other
1.1.2	Neutral
1.1.2.1	Surreal, unusual and/or novel experience
1.1.2.2	Other
1.1.3	Negative
1.1.3.1	Not engaging, feeling unconnected, strange and/or awkward
1.1.3.2	Better to write and/or speak to a real person
1.1.3.3	Concerns about how to operate the robot
1.1.3.4	Self-conscious of being filmed and/or feeling shy
1.1.3.5	Difficulty in understanding the robot sometimes
1.1.3.6	Other
1.2	**Script**
1.2.1	Positive
1.2.1.1	Clear
1.2.1.2	Other
1.2.2	Negative

1.2.2.1	Repetitive
1.2.2.2	Impersonal, generic, and/or ambiguous
1.2.2.3	Other
1.3	**Interface**
1.3.1	Instructions
1.3.1.1	Clear
1.3.1.2	Other
1.3.2	Navigation
1.3.2.1	Easy to use
1.3.2.2	Other
1.4	**Listening to oneself**
1.4.1	Positive
1.4.2	Neutral
1.4.3	Negative
2	**Motivation**
2.1	**Secondary Strategies**
2.1.1	Commitment or doing activities with friends and/or family
2.1.2	Flexibility and/or routine/planning
2.1.3	Focus on the activity or goals (reports, reminds, results)
2.1.4	Visualization, mindfulness, and/or will power
2.1.5	Good weather
2.1.6	Motivational books
2.1.7	Reminders and/or planners
2.1.8	Other
2.2	**Challenges**
2.2.1	Health problems
2.2.2	Bad weather and/or shorter days on winter
2.2.3	Laziness and/or or being tired
2.2.4	Social distractions, other things to do, setting for less, lack of time or money and/or not seeing results
2.2.5	Consistency
2.2.6	Other
3	**Engagement in physical activity after the program**
3.1	Didn't increase exercise
3.2	Planned and executed activities, increased exercise, and/or intensity
3.3	Increased activity, but didn't meet goal
3.4	Other
4	**Overall evaluation**
4.1	**Suggestions**
4.1.1	Not having the robot too close
4.1.2	Not having to press the button
4.1.3	Initial questions to get used with the robot
4.1.4	The robot could speak slower, repeat question and/or encourage to speak more
4.1.5	Lifelike and/or clearer voice
4.1.6	More specific questions and/or individualised response
4.1.7	Material could be seen by a specialist
4.1.8	Other
4.2	**Positive appraisal**
4.2.1	Space to think about things and/or voicing goals
4.2.2	Helpful making plans and/or increased motivation
4.2.3	Robot was fun, cute and/or entertaining
4.2.4	Non-judgemental aspect and/or not being interrupted

4.2.5	Innovative concept
4.2.6	Nice setting
4.2.7	Positive having face-tracking mode
4.2.8	Other

Reliability of the code

Two experienced raters applied the coding scheme to two sample units of analysis. The inter-rater reliabilities for these units (P2 and P9) were 90% and 97% respectively. After slight adjustment of the coding scheme, two new raters, who were naïve to the purposes of the study, applied the adjusted coding scheme to five more units of analysis. Their mean inter-rater reliability was 86% (range 83% – 91%). The coding scheme was assumed reliable.

Results of the thematic analysis: Participants' evaluation of the intervention

Theme 1: Interview evaluation

Participants' evaluations of the interview clustered around four sub-themes: how they felt about the interaction with the robot, their evaluation of the script, usability of the interface, and their experiences of hearing themselves speaking aloud to the robot.

Interaction/Connection with the robot (1.1)

Most participants found the interaction smooth, felt relaxed or comfortable around the robot, and enjoyed the experience. Others found the experience interesting, unusual or surreal. Most participants had an initial moment of tension followed by a period of relaxation after which they got used to the robot. Although the novelty of being in proximity to a robot contributed to the initial awkwardness, it also added to the enjoyment of the experience.

[My experience with the robot was] fine, if not a little awkward. The more time spent with the robot, the more relaxed I felt. [It was] easier to talk to than an actual person. (P2, age range: 18-25, female)

It was a very novel experience as I had never been in such close proximity to a robot before and I certainly found it engaging." (P3, age range: above 61, female)

I enjoyed interacting with the robot. It was like guided self-reflection. I was slightly nervous initially, but this soon passed and it became enjoyable. (P13, age range: 26-33, male)

[It was] fun [talking to the robot]. It made me laugh to see its eyes change colour plus its squeaky voice was a giggle. After a while I forgot about the novelty of it all and just started to answer normally. Occasionally, though, it spouted out too much verbiage and I lost the plot. Over all, a good experience and one which will remain in my mind. …It just felt like talking to a fun medical person - without the disinterested look of your average GP. (P15, age range: 43-60, female)

For some participants, the lack of a personal response prevented them feeling connected with the robot.

I don't think I interacted as I would have done a human (I tend to look people in the eyes as I talk) as I didn't feel a need to connect with it. (P2, age range: 18-25, female)

However, this participant later identified advantages of the robot over a human interviewer:

> *Was easier to talk to than a human so suppose that made the conversation more engaging in that way as I felt able to open up more but really I didn't feel as if the robot was interested in what I had to say, obviously.*

Others also drew comparisons with talking to a human, and some preferred it because they felt they could talk without being judged.

> *Strange, felt like I was talking to a human. I have never experienced an interview with a robot before so it was an unusual experience (P4, age range: 26-33, female)*
>
> *Possibly better than talking to a human as I wasn't being judged eg with bored looks, bored body language, cutting words (P15, age range: 43-60, female)*
>
> *…allowed you to be more honest as it's not a human so no judgement (P14, age range: 18-25, female)*

Script (1.2)

Most participants found the questions clear and easy to understand. Some had problems with some questions being too vague or ambiguous, having doubts about how to address them, although often they were not able to remember which questions had been problematic. Even though the robot warned at the beginning that it might sometimes ask questions that the participant had already answered, participants sometimes found it disconcerting or frustrating when this happened. This repetition could also be experienced as a positive feature.

> *Quite engaging, particularly when a question came up that I felt I had already answered, as I would have to think about the topic a bit more in order to add something to my previous answer (P13, age range: 26-33, male)*
>
> *At times I was confused as to how deeply the robot wanted me to answer the questions given, and so tended (I think) to delve too deeply as I was asked a few times to repeat what I had just said in another question. Did have one occasion where the automated voice sounded funny and wasn't sure exactly what it had said! (P2, age range: 18-25, female)*
>
> *The content was clear, each question was clearly spoken. … I found it frustrating that a question I may have already answered could be asked (P5, age range: 18-25, male)*
>
> *The content was clear. Although I felt should have been more specific to the question. Questions sounded like they could relate to another subject generally so they were too generic and therefore less personal. (P6, age range: 26-33, female)*

Interface (1.3)

The instructions were clear and the navigation easy to use and participants generally found uncomplicated to touch the robot's head sensor to advance to the next questions. However, some felt that this spoiled the illusion of a natural dialogue.

> *I felt a little concerned I might press something I should not and muddle up the process but it was fine. (P3, age range: above 61, female)*
>
> *Once I had stopped giggling at the eye colour change, everything was straightforward. Tapping on the head of the robot for the next question was simple. (P15, age range: 43-60, female)*
>
> *[The worst aspect of the interview was] not having the immediate response, having to push a button on his head made it feel fake (P4, age range: 26-33, female)*
>
> *… It was extremely life like but having to tap it on the head to confirm you had completed your answer broke the rapport slightly. [The interface was] easy to use, it spoke clearly. It was good how his head followed your movement. (P6, age range: 26-33, female)*

Listening to oneself (1.4)

Most participants found listening to themselves important. It helped them appreciate the importance of their goals and face the reality of their current behaviour and plans for change. Some did not feel comfortable in speaking out loud and found the situation awkward.

> *[Listening to myself was] very important. It's easy to rationalise unhealthy behaviour in your head but the second you realise how stupid you sound rationalising or how reasonable your reasons are for*

wanting to do it, your attitude changes. (P2, age range: 18-25, female)

[Listening to myself was] very important. Makes the thoughts hold more weight and actually think about them more than if they are simply passing thoughts. (P9, age range: 18-25, female)

I regularly discuss behaviour with a team mate, so it is something that I consider is generally important. Usually when we discuss our behaviour, we critique errors and try to improve by correcting them. However, the robot also made me talk about times where my behaviour had been positive and this is something I think is very important. (P13, age range: 26-33, male)

Actually, [listening to myself was] really rather important, as I could hear myself suggesting things, then getting a bit doubtful, then more confident as time went on. Hearing myself talking out loud made me feel as if I was chatting to myself and truly sorting out issues - without anyone else poking their nose in. (P15, age range: 43-60, female)

I actually feel writing it down allows you to express yourself more honestly without the fear of sounding silly. (P6, age range: 26-33, female)

Theme 2: Motivation

Participants' spontaneous strategies (2.1) for supporting motivation included commitment or doing activities with friends or family; flexibility, routine, or planning; focusing on the goals; visualization techniques, mindfulness, or will power; motivational books.

> *Using notifications on my phone to remind me when I have to do whatever it is I have to do [helps me staying motivated]. Also using diaries or planners to tick off when I've done it. (P2, age range: 18-25, female)*

> *[What helps me the most in staying motivated] is being mindful of the situation. (P3, age range: above 61, female)*

> *… visualising my goals and setting out steps I can achieve in the short term in order to achieve the long term goal. (P5, age range: 18-25, male)*

> *…Friends making supportive comments (P15, age range: 43-60, female)*

Participants wrote about challenges (2.2) that make it hard to keep themselves motivated, including health problems, bad weather, winter, laziness or being tired, and social distractions.

> *[The hardest part in keeping myself motivated is] being distracted by something I shouldn't be (like playing a video game for too long or watching another episode of something on Netflix.) (P2, age range: 18-25, female)*

> *… tiredness, lack of time due to work. Winter when the days feel shorter. (P6, age range: 26-33, female)*

… erratic work shift patterns. Also, not seeing results within a certain timeframe can be demotivating. (P13, age range: 26-33, male)

Theme 3: Engagement in physical activity after the program

There was mixed success in terms of whether participants achieved their goal for the week after the robot interview. Some felt disappointed that they had not done so:

I didn't improve my physical activity. It has been more or less the same as the past weeks. (P12, age range: 18-25, female)

I did go for a run with a friend, as I said I would in the interview, however, this only happened once and so I feel it had not worked as well as maybe I had hoped. (P18, age range: 18-25, female)

Others achieved their goals and occasionally expressed surprise in the way they communicated their success. For example, one participant reported, "*I actually carried out my plan…" (P9, age range: 18-25, female).*

I stretched 3 out of 7 days and practised burlesque on 1, which is way more than I'd done regularly before. (P2, age range: 18-25, female)

I completed at least 20 minutes of additional physical activity every day. (P4, age range: 26-33, female)

Theme 4: Overall evaluation

Participants' positive appraisal of the intervention focused strongly on their perception that the robot was not judging them whereas a human might have done. They liked being able to talk without being interrupted and appreciated how the interview gave them space to think about things and voice their goals. One participant described this as *a kind of "liberation" (P12, age range: 18-25, female).*

> *[The best aspect of this robotic interview was] being able to talk freely and for as long as I wanted about every aspect of physical activity that concerned me without being judged. (P2, age range: 18-25, female)*

> *… the time to talk without being interrupted. (P4, age range: 26-33, female)*

> *… he didn't interrupt and was not judgemental… I felt more motivated because I talked through my goals without interruption or other people's advice (P10, age range: 34-42, female)*

> *The robot interview allowed me to reflect on my behaviour in a guided manner. It also encouraged me to focus on positive behaviour from the past and specific changes that I need to make for the future. I felt that this was the best aspect. When reflecting on my behaviour alone, there is a tendency to dwell on things done wrong and this does not always provide a solution. The robot demonstrated that I can reflect on my behaviour without focusing on negative aspects. (P13, age range: 26-33, male)*

> *The best part was the whole idea that I was able to interact with a robot. I think it feels nice to talk and not feel embarrassed by potential judgement. (P18, age range: 18-25, female)*

I felt I can talk freely without any judgement which was quite nice. Talking to 'a human' is quite daunting as we naturally judge things and people especially people's behaviour. (P19, age range: 18-25, female)

The novelty of the robot was a positive feature for some. One participant explained how the fact that the interview was fun and memorable led her to share her goals with others. The robot may thus have contributed to that participant gaining '*support from others*', which she cited as something that helps her stay motivated.

The use of a robot made it fun and less pressured which stayed in my mind longer…it played on my mind during the past week and I told others about the robot which made them ask about the goals set during the interview (P1, age range: 18-25, female)

It was engaging, different and fun…the fact i have thought about it over the past week has been motivational (P3, age range: above 61, female)

Participants offered insights into how the robotic interview could be improved. Common themes were the problem of not being able to replay a question that had not been understood, needing some time to get used to the robot, and wanting a more natural way of progressing to the next question.

I feel that the interview could be improved by having more off topic questions to begin with allowing the person to get used to the robot. (P5, age range: 18-25, male)

[The robotic interview could be improved by] not having the robot to close, although that is essential to a certain extent, just felt awkward sitting so close- maybe it could be placed more to the side? (P2, age range: 18-25, female)

Having to repeatedly touch the head for the next question was a little off-putting. (P9, age range: 18-25, female)

Maybe it would be useful to have the robot repeating the question. (P12, age range: 18-25, female)

[The worst aspect of this robotic interview was] having no feedback on my responses so I didn't know if I was answering the question correctly. (P14, age range: 18-25, female)

Perhaps a clearer voice. Sometimes, I felt I felt that I might have misunderstood a question due to not understanding the robot as well as I had wanted. (P18, age range: 18-25, female)

Discussion

We developed a technology-delivered adaptation of MI using a humanoid robot. When MI is translated into technology as a medium, this person-centred counselling technique inevitably loses its full capacity; however, we have developed a script with strong elements of MI including evocation, promoting self-efficacy, strengthening commitment to change, and asking open questions. Key findings from participants' evaluation of the intervention were that they found it motivating to hear themselves discussing their behaviour with the robot; they enjoyed the interaction and found the robot easy to use, but wanted longer to get used to it; and they liked the neutrality of the robot. The main drawback was that the robot could not tailor its questions according to the answers already given.

Previous research with technological delivery of MI has typically used text-based responses, for example Gerbert's work with the Video Doctor (Jackson et al., 2011; Tsoh et al., 2010; Humphreys et al., 2011). In a more ambitious project than ours, Kanaoka and Mutlu (2015) used a NAO robot to deliver a motivational interview with personalised responses to the participant's speech. In contrast to their predictions, participants were less motivated after the MI dialogue than after a monologue in which the robot gave advice. Kanaoka and Mutlu attributed this finding to inadequacy of the speech recognition software. They noted that the robot sometimes interrupted participants and that, when the robot 'misheard' them, participants spoke to the microphone rather than to the robot, suggesting a breakdown in the fluency of the interaction. We tried to avoid these problems by using the robot to deliver a series of open questions and requiring the participant to press the robot's head sensor when they had finished talking and were ready to advance to the next question. Participants evaluated this aspect of the interaction positively and negatively. They liked the space to talk freely about themselves, without interruption, and reported that the robot's questions prompted them to think deeply and realistically about their goals and obstacles to achieving them. However, pressing the head sensor broke the flow of the conversation for some. The lack of personalisation was frustrating, particularly when the robot asked a question that participants felt they had already answered. We had tried to preempt this problem by having the robot warn participants at the start that it might repeat a question. The interview deliberately asked several questions on one topic before moving to the next, to encourage the participant to think deeply about the issue and why it matters to them. This outcome would normally be achieved in MI through the interviewer reflecting the meaning of the participant's answer back to them. Although participants typically disliked the repetition, one participant found that it helped him feel engaged in the dialogue by encouraging him to add more information to his previous answer.

An important aim of MI is to elicit 'change talk', where the individual articulates their desire or need to change. The extent to which a motivational interview elicits such talk is positively associated with outcomes (Apodaca & Longabaugh, 2009). In the present study, participants found it motivating to hear themselves argue aloud for change, reporting that it helped them consolidate and take ownership of their plans. Many but not all participants felt that the interview had a positive effect on their behaviour in the week that followed.

As most people do not have access to humanoid robots, the interaction with a NAO robot acting as a counsellor was a unique experience. Because of the singularity of the situation, participants remembered the interaction and talked about it with other people, reiterating their commitment to change and making a social contract (Cavedon & Sonenberg, 1998; Cudd, 2014). Further research is needed to test whether the effect of the interview fades away once the novelty wears off.

Although participants criticised the interaction for not being as fluent as a conversation with a human interviewer, some benefits of the robot interviewer featured very strongly in participants' evaluations. They felt unhurried, because the robot did not interrupt them, and many felt more comfortable discussing issues with the robot than with a human counsellor because it would not judge them. A central tenet of MI is that interactions should be collaborative and not judgemental. The present findings are an important reminder that, however skilled the interviewer, participants bring their own assumptions and anxieties to the interview, including a fear that the interviewer will judge them. In line with these findings, there is evidence that people will more willingly reveal sensitive information to computers than to humans (Humphreys et al., 2011; Gerbert et al., 2003; Pickard, Roster, & Chen, 2016). In the drive to develop increasingly naturalistic computer-human interactions, developers must keep sight of the advantages of being perceived as a robot.

Participants spontaneously used a range of strategies to motivate themselves, including setting reminders, engaging peer support, having a routine, and visualising their goals. As challenges to achieving their goals, they cited competing distractions, tiredness, and lack of time. There is scope for developing the robot interaction further, to encourage successful behaviour change strategies and reduce counterproductive behaviours. Previous work has shown that people can develop social relationships with robots (Baxter et al., 2017). Future research could explore the value of the robot for providing social support, which is known to facilitate behaviour change, at challenging moments like those mentioned by participants. This social support could include the ideas suggested by participants, like reminding them of their plan, providing encouragement, or using imagery to strengthen motivation, for example by guiding visualisation of the goal and how good it will feel to succeed (Andrade et al., 2016).

Participants wanted some time to get used to the robot before starting the interview. Providing a longer introduction before beginning the motivational interview could help address some of the drawbacks identified by participants, including discomfort at being close to the robot and having to touch it, and difficulty understanding its speech.

Limitations of this approach include the impossibility of using all MI skills in a pre-scripted interview. Without more sophisticated speech recognition and branching logic, the robot is unable to reflect the participant’s meaning, affirm their choices and autonomy, or summarise what they have said (although we included suggestions, by the robot, that the participant summarise their plan). Even with perfect speech recognition, sophisticated MI skills like rolling with resistance and identifying change talk and sustain talk present a considerable challenge. However, even without these skills, there is evidence that technological adaptations of MI can be beneficial (Shingleton & Palfai, 2016). There is potentially an issue of safety, in terms of how a robot might respond to a participant who proposes a dangerous course of action. However, a skilled MI practitioner would elicit the participant’s appraisal of their plan, rather than directly advising against it, and this approach could be reproduced in the robot, as we did in the current intervention through asking questions that probed an issue deeply before moving to the next. One solution to the problem of participants not knowing a safe solution to their dilemma could be for the robot to ask permission to offer advice or information. The NAO robot’s head, hands and feet sensors also provide opportunities to follow different paths through the pre-scripted interview–for example, participants could choose information about diet by pressing a hand sensor or about exercise by pressing a foot sensor. Adding limited choice in this way may help to focus the interview on issues that matter most to participants, and provide an experience that feels more personal.

The study has several limitations. It focused on participants' experiences of the interaction and impressions of its impact on their behaviour. Participants responded to an advertisement for volunteers who wanted to increase their physical activity, but we did not assess their motivation, baseline activity levels, or changes in behaviour after the interview. Further research should test the robot interview with different populations, including those who wish to start being physically active and those who wish to increase their activity, and measure their pre- and post-intervention motivation and behaviour. Another limitation is that the people who volunteered for this study were members of a research panel and fairly used to strange experiences in psychology laboratories.

They may have been more accepting of the robot, despite meeting it for the first time, than other members of the general population. Having established the acceptability of the intervention using qualitative methods, an important next step is to test its efficacy for changing behaviour in a broader sample. Randomized controlled trials are needed to assess quantitative changes in motivation and physical activity associated with the robot intervention and compare them, in the first instance, against simple information and advice. To maximise the potential for observing benefits over meaningful timescales, we suggest that a series of interactions be designed to incorporates reminders and follow-up sessions, so the robot provides ongoing support for behaviour change.

Much could be learned from observing the participant-robot interaction but interviews were not recorded because participants who helped with the initial development thought they would feel uncomfortable being watched or filmed to while talking to the robot. Having completed this study, we are less concerned that this would be an issue. A familiarisation phase, with some general conversation between the participant and robot before starting the motivation interview, could help reduce the strangeness of the experience. In a related study evaluating a motivational interview delivered by a human video-counsellor, analysis of participants' speech showed that the interview successfully elicited change talk (Study 1). Combining analyses of change/sustain talk with quantitative data on behaviour change could reveal whether a robot-led motivational interview affected motivation and behaviour via the same mechanisms as human-led MI.

A robot-delivered motivational interview may lack elements of an interview with a human counsellor, but our findings suggest it could have wide application. Because participants enjoyed the interaction and liked the novelty, a robot-delivered interview may help engage people to discuss sensitive issues and to get a feel for what counselling would be like, encouraging self-help or help-seeking earlier in the time course of a problem. A robot interview could be designed that encouraged people who are not yet contemplating change, to consider its pros and cons. The novelty of interacting with a robot could encourage people to engage who might not feel ready to talk to a human counsellor. Given that our adult participants were concerned about being judged by another adult, the robot could be particularly important for encouraging children and adolescents to discuss mental health issues as they may be more susceptible to fears of being judged or misunderstood by an adult. As well as fostering engagement with healthcare, a robot interviewer could also provide motivational ‘after-care’, ensuring that benefits from a human-led intervention are sustained when the intervention ends. The generic nature of the interview means it can easily be modified for wide variety of target behaviours, potentially providing motivational support for the very large number of people who struggle with conditions such as addiction or obesity but do not meet the criteria for accessing professional support.

Conclusion

We have shown, for the first time, that a motivational interview delivered by a social robot can elicit out-loud discussion from participants in an interaction that they perceive as enjoyable, interesting and helpful. Participants especially found it useful to hear themselves talking about their behaviour aloud, giving this new intervention a potential advantage over other technology-delivered adaptations of MI. Concern about being judged by a human interviewer came across strongly in praise for the non-judgemental nature of the robot, suggesting that robots may be particularly helpful for eliciting talk about sensitive issues.

Chapter 5: Secondment at Queensland University of Technology (QUT)

A requirement of CogNovo was that each research fellow spend some time working with a project partner in another institution. This chapter reports on a 3-month secondment to Professor Kavanagh's lab at Queensland University of Technology (QUT), and explains how the ideas in this thesis developed during that time.

The secondment at QUT's Centre for Children's Health Research (Figure 5.1) in Brisbane, Australia, took place from August until October 2015. The time spent in Australia included several meetings with three supervisors, David Kavanagh (QUT), Jackie Andrade (Plymouth University), and Jon May (Plymouth University) in August. We discussed the current stage of the project and future studies possibilities. At this point, we had run the two qualitative studies in Plymouth with a video counsellor and a robot counsellor delivering a motivational interviewing for encouraging physical activity documented in Chapter 3 and 4.

In Australia, we accessed participants' qualitative responses relative to Study 1 and 2, being able to weigh the strengthens and weaknesses of these two empirical studies. The time was used to analyze the results and design the next experiment. We decided to run a follow-up study in Australia to test the effectiveness of the virtual MI directly comparing a video robot with a video counsellor delivering MI against a control group. Unfortunately, the bureaucratic ethical clearance at QUT took longer than expected and the trial was not put into action due to the secondment time restriction.

Figure 5.1. Centre for Children's Health Research in Brisbane where the secondment took place.

Trial development

In Australia, we considered the preliminary results of these two qualitative studies in the broader context of the team's collaborative research. We decided to take advantage of the secondment to collect quantitative data on the impact of the intervention on physical activity to verify the effectiveness of this virtual intervention. It was a valuable experience to discuss the possible future experiment with the Australian supervisor, David Kavanagh to define the study design and familiarise myself with the research procedures of another institution.

There would be three groups, one receiving the virtual intervention with a human video counsellor, another with a robot video counsellor, and a control group consisting of participants in the waiting list for the virtual intervention. Having tested the 'live' robot counsellor in Study 2, we switched to video delivery of the script for this planned study so we could compare the human and robot counsellor without confounding effects of delivery mode. The remote delivery for the robot would be a method to reach more people as technology and at the same time not rely on a researcher to monitor the robot compared to a live interaction. The same human video counsellor from the previous experiment was going to be used in this trial, however, we decided to subtitle the videos for a greater comprehension. Participants in studies 1 and 2 reported that sometimes they had not heard or understood the video-counsellor or robot's questions, and subtitles provide a solution to this problem.

The subtitles were sent to the Plymouth University School of Psychology's Technical Office who updated the web version of the video counselling interview. Remotely, I guided a student assistant based in Plymouth to record a raw video of the robot delivering the MI script. The student assistant sent me the files and I edited them in Australia. The final videos were sent to the Plymouth University School of Psychology's Technical Office for developing a web version of the robot counsellor videos for the study together with the appropriate subtitles. These materials for the trial were ready in August.

Study design

The study design was developed and explained as follows.

This pilot project aims to test new technological tools to encourage physical activity. Psychological theory and practice in motivation enhancement has been used to create virtual health interventions that use standard questions *that are delivered by video. We explore whether these novel interventions are acceptable and effective in changing behaviour.*

The project compares the effects over a week, from a video interview delivered by a human or by a robot, against changes that occur in a control group that receives the robot video after a 1-week delay.

We expect both video interviews will result in increased motivation and physical activity levels, compared with the control. However, we expect the delivery by the robot to be more readily accepted (because we expect participants to be more forgiving of the standardised delivery from a robot), and that the robot interview will have greater impact on subsequent activity than the interview by the human coach.

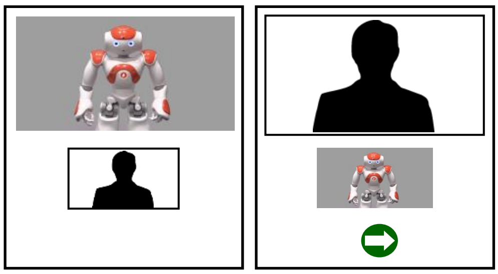
If further refinement of these methods does produce significant behaviour change, the research program will have identified a strategy that is likely to be highly cost-effective and capable of wide dissemination.

The aim of this project is to test a virtual health intervention with video counsellors (humans and robots) based on motivational interviewing (a counselling technique based on an empathetic person-centred style) for goal setting and planning of action for physical activity, in healthy people who want to increase their activity levels.

We will conduct a randomized controlled trial with three groups:

1. *Video interview with a human,*

2. *Video interview with a robot,*



3. *Control (delayed video interview with the robot)*

Figure 5.2. Study design.

Session 1 will be administered in a QUT laboratory and consists of completing online questionnaires about current physical activity, and confidence and motivation concerning increasing activity. Participants randomly allocated to a video interview will then receive it.

Session 2 will be held one week later. We will re-administer the same questionnaires as Session 1 plus a Working Alliance questionnaire. In the first two groups, this is followed by a structured interview about the participants' experience. Participants in the control group then receive the video interview with the robot.

QUT ethical application

For the study to to occur in Australia, we submitted an ethical application for negligible/low risk research involving human participants to QUT's ethical committee. It consisted of a series of documents: application for review of negligible/low risk research involving human participants; risk assessment; consent forms; and flyer/email for recruitment.

QUT ethical application development

Designing and applying for ethical clearance at QUT was more bureaucratic than at Plymouth University. We submitted the application with all the official requirements; however, in the middle of the process, we realized that we would not have enough time for running the whole experiment in Brisbane. The approval for the study took longer than David Kavanagh had predicted and was not confirmed until after I left Australia. Overall, the experience was not wasted. I have learned the process of an ethical application in another institution. The writing process clarified some weaknesses of the trial we were going to run. We had more time to rethink our approach to this trial and plan it in more detail for running an improved version back in the UK, which is reported in Chapter 6.

Meanwhile, I had time to analyse the results of the previous qualitative studies (Chapter 3 and 4) that were run in the UK. I could share the results with the supervisors which was valuable to guide the next steps of the research. I developed a specific content analysis coding system to be applied to each of the studies.

NAO Robot Acquisition and Training

The results of these previous studies were shared and discussed with the supervisors. As the robot was well accepted by participants as a novel means for delivering a behaviour change intervention, David Kavanagh decided to apply for an equipment grant to acquire a NAO robot for the Centre for Children's Health Research. The grant application succeeded, allowing purchase of a NAO robot to research remote delivery of motivational interventions, following up the interventions we developed on our CogNovo project 13. Following my secondment, David Kavanagh's PhD student, Nicole Robinson, secured a travel grant from Queensland University of Technology and visited Plymouth University from 22nd April to 15th May 2016 to work with the Project 13 team to learn how to use and program the NAO robot with Choregraphe software for delivering psychological interventions. Further training also involved video and audio recording the robot for remote delivery. In this way, my secondment has influenced our project partner's direction of research. After Nicole's training and using the expertise acquired with us, she had the opportunity of running three studies in QUT. The first study was about interacting with a social robot to decrease high sugar and fat snack and drink intake over an 8-week period for adults from the general community. It consisted of two 60-minute FIT delivered sessions and one 10-minute video with immediate and 4-week delay conditions. The second study involved a robot-delivered intervention with type 1 diabetic adolescents between 11-17 from a hospital outpatient clinic. There was a pilot trial with 8 week intervention, two 10-minute videos and two 60-minute face-to-face sessions delivered via robot using FIT. The third study consisted of two conditions of humanoid and mechanical behaviours in a single session laboratory study using an adolescent sample to better understand acceptable, likeability, and intention to use a robot in the future.

In Plymouth, I trained Leonie Cooper to program and work with NAO for her master thesis project entitled, 'Are robots the future in behaviour change? Testing Functional Imagery Training in a physical activity intervention'. Her master's thesis was born from the work developed in Australia with ideas for NAO's remote delivery and using a minimal FIT script developed at QUT.

Children’s Hospital Foundation Research Grant Application

Besides acquiring a NAO robot, David Kavanagh and I together with a group of researchers also developed a grant application for the Children’s Hospital Foundation Research for a project entitled: A new e-assisted motivational intervention for health maintenance behaviours using mental imagery. The proposed research incorporated the expertise we have developed in Plymouth on the CogNovo project 13. We proposed to explore delivery of FIT via a robot that would be programmed and video-recorded in Plymouth for delivery at QUT. Unfortunately, the grant application was not successful, but it was a stimulus to developing new applications of Project 13’s work. Nicole Robinson at QUT has been developing some of these ideas for her PhD.

Functional Imagery Training (FIT) script development

For the next step of research, we developed a functional imagery training (FIT) script to be used in virtual delivery. David Kavanagh has developed FIT as a novel motivational intervention based on the theoretical work that he did with Jackie Andrade and Jon May. FIT trains the participant in multisensory imagery of their goal, how they will work towards their goal, immediate benefits of doing so, and strategies for overcoming obstacles. The focus on imagery is unique to FIT and potentially makes FIT particularly suitable for remote delivery, because the intervention is less dependent on a verbal conversation with the therapist. We planned that the next stage of Project 13's research programme would test FIT delivered by the video counsellor and robot, and to compare it with MI. An important task during the secondment was to develop scripts for remote delivery of FIT.

For the FIT script development, we considered that every step should be conducted via imagery. The FIT script contained imagery exercises on the following topics: a neutral imagery exercise (the lemon exercise, based on Holmes & Matthews, 2005) to demonstrate that imagery can be multi-sensory, affective and linked to physiological responses; downsides of the current behaviour and benefits of change; developing a hypothetical goal and implementation intentions; overcoming challenges that might arise; and using pictures and reminders to practice imagery routinely.

A FIT script was developed with David Kavanagh to be used in the future remote interventions to be run in Plymouth. More details about the FIT script development is reported on Chapter 6.

Conclusion

Brisbane was a very pleasant city to have a secondment. I appreciated the opportunity, which was an interesting academic experience and enriched my professional development within this program.

Several meetings with my supervisors (Jackie Andrade, Jon May, and David Kavanagh) took place in August followed by other one-on-one meetings with David Kavanagh in September and October. These meetings were essential for understanding the next stages of CogNovo project 13.

We developed the next steps for the project, including an ethical application for running a trial in Australia. Unfortunately, the ethical application clearance was more bureaucratic than expected, disabling the idea of running a trial there. However, the experience of writing a formal ethical application clarified our trial study design and led to further improvements of it.

Besides gaining a general impression of how research is conducted in another institution with different requirements for an ethical application, I could also delve into the results from two studies that we had run in Plymouth right before my secondment, a qualitative analysis of a video counsellor and a robot counsellor reported in Chapter 3 and 4. By examining the results of these studies, I could discuss the participants' impressions and evaluations with my external supervisor. This discussion led to the development of new studies for my PhD, including the development of a FIT script for other empirical investigations and how FIT could be more adaptable into the technologies I used for the first two studies. The exchange of ideas also led to the acquisition of a NAO robot for the

Centre for Children's Health Research and submission of a grant application to use the intervention that we have developed on CogNovo's project 13.

The secondment has also had a broader impact in terms of strengthening and widening the interdisciplinary collaboration between clinical psychologists at QUT (David Kavanagh, Leanne Hides) and University of Queensland (Jason Connor, Matt Gullo), and cognitive psychologists (Jackie Andrade, Jon May) and roboticists (Tony Belpaeme) at Plymouth University.

Chapter 6: Study 3 - Motivational Interviewing versus Functional Imagery Training for encouraging physical activity delivered by a video robot

Introduction

In Study 1 and 2, even though participants valued listening to themselves talking aloud in a technologically delivered MI, they also reported disappointment with the lack of personalised response and reflection by the virtual coach. In Study 2, the non-judgemental nature of the robot was positively appraised by participants, which shows that certain types of technology could even present advantages compared to a face-to-face human delivery. However, a face-to-face robotic MI requires human input to monitor the machine from another room, reducing its potential to increase access to counselling. In this current study, we attempted to tackle some of these limitations by developing a screened robotic motivational session, avoiding the need for human monitoring; and by introducing FIT as a counselling technology that focus on mental imagery, which we expected to decrease participants' expectation of a personalised response.

Functional Imagery Training (FIT) (Kavanagh et al., 2014) builds on MI knowledge, integrating a further component—mental imagery exercises—based on the Elaboration Intrusion (EI) Theory (May et al., 2012), which posits that intrusive thoughts of desire lead to multisensory imagery elaboration affecting behaviour. FIT is potentially more adaptable to remote delivery than MI because more of the psychological work is done through imagery, reducing dependence of a empathic responding from the therapist. Initial empirical testing of FIT, delivered face-to-face, has shown that it reduces snacking (Andrade et al., 2016; Solbrig et al., 2017). A randomised controlled trial of FIT, delivered by human face to face and via telephone, resulted in substantially greater weight loss compared with the same amount of MI (Solbrig et al., 2018). Although FIT is a very new intervention, there is already some evidence for benefits relative to MI.

We expected that there would also be an advantage of FIT versus MI in automated deliveries. Most participants in a focus group with participants attempting to lose weight positively evaluated screenshots from a FIT app prototype and considered that it could help them sustain motivation (Solbrig et al., 2017), showing that there is an opportunity for this counselling technique to be delivered remotely. Some researchers have used mental imagery virtually to motivate behaviour change with positive outcomes (e.g., Lang et al., 2012; Murphy et al., 2015; Blackwell et al., 2015), but a remotely-delivery counselling session as FIT has not been developed.

We aimed to develop a virtual intervention that would incorporate FIT-style mental imagery exercises into the adapted motivational interview used in studies 1 and 2. Virtual FIT has not only the potential to be more efficient than MI as a counselling technique, as shown for face-to-face delivery of FIT compared with MI. It could also help address the limitation that emerged from studies 1 and 2, that participants felt the dialogue was rather impersonal. By focusing on mental imagery exercises, an automated version of FIT could increase the extent to which the participant is determining the course of the intervention, helping the intervention to feel more personalised without increasing demands on the technology to recognise speech and respond accordingly. We anticipated that FIT would outdo MI in its automated delivery for both the higher potential for behaviour change and its more prone adaptability to technology.

Studies 1 and 2 explored participants' experiences of the intervention but did not test if there was an effect on behaviour. Mental imagery evokes greater emotional responses as well as it is more likely to be treated as being 'real' or to promote associated behaviour than verbal representation (Holmes & Mathews, 2005). For being more salient than verbal interaction, we predicted that FIT would not only have a greater impact on physical activity than MI, but also on self-efficacy and goal motivation. Both MI and FIT's aims are to increase motivation and self-efficacy. However, in a review about mechanisms of change within MI in relation to health behaviours outcomes, MI improved self-efficacy in only two examined studies (Copeland et al., 2015). FIT's stress on mental imagery could possibly lead to a higher impact on goal motivation and self-efficacy. In a study to test the effect of mental imagery training in sports, self-efficacy and performance increased compared to a group on relaxation training and a control group with no training (Karimian, Kashefolhagh, Dadashi, & Chharbaghi, 2010). FIT has shown to enhance grit in professional soccer players as well as vividness of goal imagery (Rhodes et al., 2018). The professional players also perceived an improvement in their sports performance after FIT. As FIT enhances MI with mental imagery exercises, we predicted that participants picturing themselves in situations where they succeeded in performing their goal behaviours would also increase their self-efficacy and motivation more than MI.

As cited previously, Palfai and Shingleton's (2016) review show that researchers have used different mediums—text, audio, video, and animations—to deliver MI remotely. The use of video and avatars have been shown acceptable in the majority of studies investigated. However, one of the main challenges faced by automating MI is the dialogue factor and providing virtual feedback. Participants' reponses interacting with the video functionalities have been done by text (e.g., Alemagno et al., 2009; Gerbert et al., 2003; Osilla et al., 2012). Nevertheless, as discussed in Chapter 3, change talk is one of the main effective ingredients of MI (Apodaca & Longabaugh, 2009). Giving participants the opportunity to speak out loud exploits this fundamental benefit of the original face-to-face MI. Participants showed high rates of change talk in Study 1 compared to sustain talk and in both studies 1 and 2 participants positive evaluated speaking about their goals and motivations out loud. However, they also expressed discontent with the lack of smoothness in the interaction. Focusing on mental imagery, FIT could have an advantage over MI assuming that participants would have lower expectations regarding a personalised feedback because there would be a focus on a mental engagement.

Robots could also counteract the frustration of not having a customized response. People hold lower expectations when interacting with a less realistic representation than human-like ones (Slater & Steed, 2002). Robots have been recently applied as counsellors with terms as robopsychology and robotherapy being coined (Libin & Libin, 2004). A NAO robot has been employed to deliver MI, but no difference was found between MI and a monologuial traditional advice condition (Kanaoka & Mutlu, 2015). The experimenters suggested that the inadequacy of dialogue fluency might have impacted the results as they used speech recognition that had problems with backchannel interruptions. In the face-to-face robotic MI in Study 2, a simpler interface with no speech recognition was used to tackle this incongruency problem.

Fasola and Matarić (2013) compared a physically present robot with a screened version of the same machine encouraging physical activity. The two conditions led to similar levels of task performance even though the participants rated the condition with the physically present robot more enjoyable (Fasola & Matarić, 2013). There results encouraged us to use a video robot for the potential to reach a greater number of people as opposed to depending on a professional to monitor a physical robot. We intended to retain the non-judgementality of the robot reported in Study 2 but with a remote delivery that could increase access with the potential of being embedded into websites and mobile applications.

We tested our intervention in the context of physical activtiy, keeping the same target behaviour as studies 1 and 2.

In this study we compared a MI and FIT intervention—delivered by a video robot—in relation to a control group to understand the potential of implementing mental imagery exercises into MI. We predicted that the FIT and MI intervention would lead to greater motivational and actional impact on participants' physical activty compared to the control group, but that FIT would show an advantage in comparison to MI. We used the IPAQ for being a well-established and cost-effective physical activity assessment with a cross-country reliability and validity (Craig et al., 2003). The General Self-Efficacy Scale is another cross-country reliable and valible assessment that measures the belief that one can perform novel or difficult tasks as well as coping with adversity (Schwarzer & Jerusalem, 1995). The Goal Motivation Scale captures both the strength of current behaviour and frequency of motivation cognitions over the past week, which other forms of assessment do not assess (Kavanagh et al., n.d.).

Methods

Participants and Design

A total of 98 participants were recruited from the School of Psychology's research participation pool in response to an advert for people wishing to increase their physical activity levels. Eighty-six completed baseline and follow-up sessions and were included in the analysis; 12 dropped out. Age ranged from 18-83 years old. Twenty-two were male and 64 were female. Psychology students were given credit points for their courses and volunteers were paid £8 per hour. Participants were randomly allocated in three different conditions: (1) video robot delivering MI (n=28); (2) video robot delivering FIT (n=31); and (3) control group comprised of a delayed treatment (n=27). All participants completed the IPAQ at baseline and participants in MI and FIT underwent the videoed intervention. Two weeks after, all groups completed the IPAQ, self-efficacy general scale, and goal motivation scale plus a qualitative questionnaire. Participants from the control group underwent a videoed intervention.

Materials

Motivational interview (MI) script

The MI script consisted of open questions similar to the previously developed versions from Study 1 and 2 with slightly changes in some of the sentences to improve the robot's diction. As stated in Study 1 and 2, the core of the script was inspired by sample questions from Miller and Rollnick's book (2002) with the following main topics: advantage of change and disadvantages of the status quo, optimism about change, intention to change, evocation, hypothetical change, setting goals and arriving at a plan. This MI script was rated according to Shingleton and Palfai's (2016) as also described in Study 1 and 2 with strong ratings for evocation, provoking self-efficacy, strengthening commitment to change, and asking open-ended questions.

Functional imagery training (FIT) script

The FIT script added mental imagery exercises related to each section of the MI version. Mental imagery exercises were incorporating into each component of the MI script. The script started with a warm-up mental imagery exercise—imagining holding, cutting, and tasting a lemon (Holmes & Mathews, 2005)—to illustrate how imagery should involve all senses. After this introductory task, questions based on MI began. A question about advantages or disadvantages of the status quo, for instance, was followed by an imagery exercise to construct specific situations in the participant's mind about the same topic. Below there is an excerpt of the FIT script to illustrate the interweaving between typical MI questions and mental imagery exercises.

Is there anything that would get better if you increased your physical activity?

(listening video)

How would that affect you?

(listening video)

Would you notice any changes after you did it for a month?

(listening video)

What about after the first week? What early changes would you notice?

(listening video)

Let's imagine that you did succeed at becoming more active. Think of a time when you may experience some of these improvements.

(pause)

Visualise where you are...

(pause)

what is happening around you...

(pause)

how your body is feeling...

(pause)

and how you feel within yourself, emotionally.

As demonstrated in the excerpt above, the script indicated the pauses after mental imagery exercises for the participant to engage mentally. After verbal questions, there was a 'listening' video, inviting participants to speak their answers out loud.

Programming and recording the NAO robot

The MI and FIT scripts were programmed into a NAO robot using Choregraphe software, which sends instructions wirelessly to the physical robot. As in Study 2, the default pitch was preserved while the speed of speech was adapted to around 80%, aiming at an understandable rhythm. The inbuilt breathing function was used to simulate natural movement.

Each script was video recorded separately. A 'listening' video consisted of the NAO robot gently moving, programmed with the breathing function. The recording was executed against a green screen background. In post-production, the backdrop was substituted by a solid grey for a neutral atmosphere. Each set of questions, in the MI, plus the mental imagery exercises in FIT, generated a video file. The video interview was programmed in Microsoft PowerPoint with questions followed by the listening video (MI and FIT) plus mental imagery exercises with inserted pauses (FIT). The participant would reply out loud to each question and press a button on the screen to advance to the next task. They would engage with the mental imagery exercise during the pauses.

The questions were subtitled in English for easier understanding of the spoken words. A number of participants in Study 2 reported that they sometimes could not fully understand what the robot was saying due to its quirky voice. For this reason, this current version of the robotic coach included subtitles so that the participants could read the words if they did not fully understand the robot's instructions.

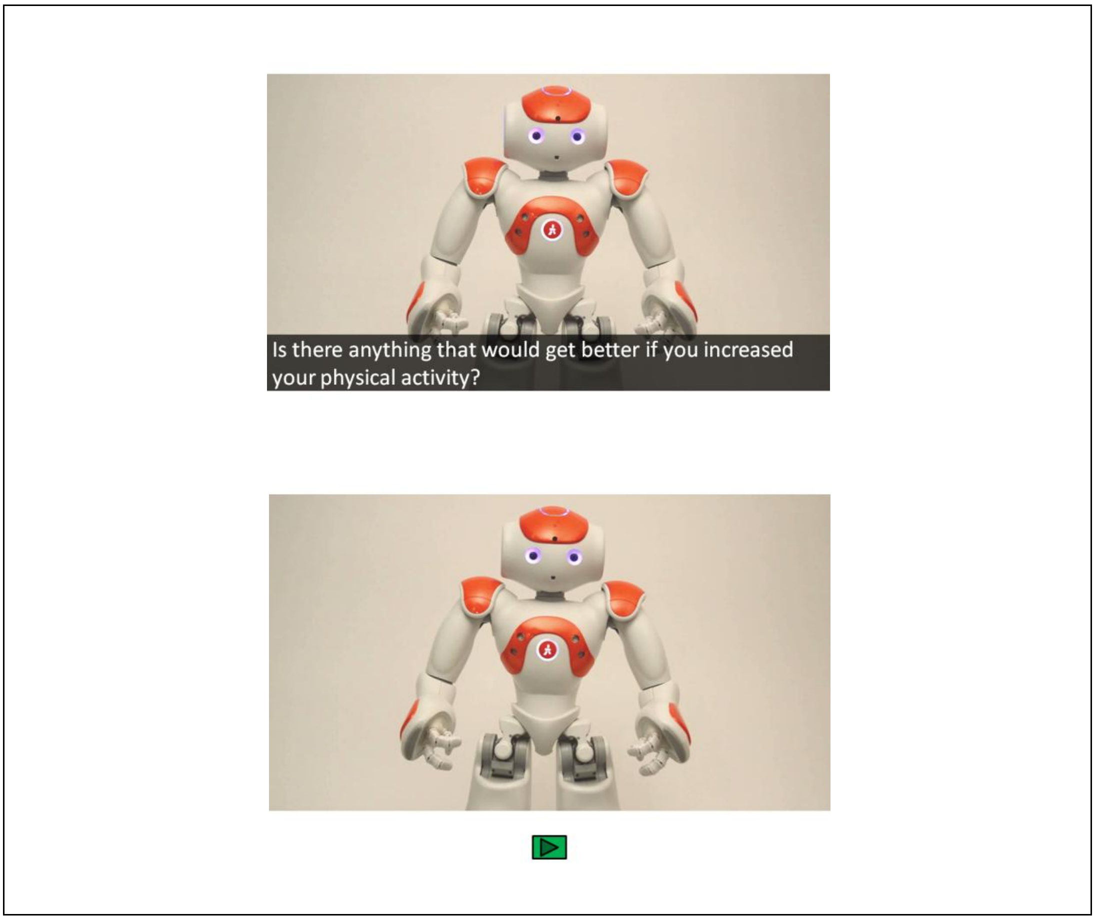


Figure. 6.1. A frame of a question video followed by a frame of the listening video with a button to advance to the next question.

Questionnaires

International Physical Activity Questionnaire (IPAQ)

The IPAQ long last seven days self-administered format for use with young and middle-aged adults (15-69 years) was developed as an international measure for physical activity followed by extensive reliability and validity tests in 12 countries ('International Physical Activity Questionnaire', 2002). The IPAQ comprises five parts: (1) job-related physical activity; (2) transportation physical activity; (3) housework, house maintenance, and caring for family; (4) recreation, sport, and leisure-time physical activity; (5) time spent sitting. Each section asks for detailed information in number of days, hours, and minutes about specific engaged physical activities.

The Goal Motivation Scale for Physical Activity (GMS-PA)

The GMS-PA (Kavanagh et al., n.d.) was derived from the EI theory (May et al., 2012). It consists of two sections: (1) Strength (GMS-PAS) and (2) Frequency (GMS-PAF). Each of the two sections contains a total of 12 questions. Both GMS sections had three subscale items: intensity of desire (GMS-PAS) or frequency of desire (GMS-PAF) to increase physical activity, vividness of imagery, and cognitive availability of thoughts about physical activity. The scale for each item goes from zero to ten. In GMS-PAS from 0, not at all, to 10, extremely. In GMS-FAF from 0, not at all, to 10, consistently (see Appendix 6.1). Due to a mechanical error, the last question of GMS-PAS section was omitted in the electronic questionnaire resulting in 11 questions out of 12. The GMS-PAF was complete with 12 questions.

General Self-Efficacy questionnaire

The general self-efficacy questionnaire (Schwarzer & Jerusalem, 1995) contains 10 questions with a rating scale of four items (not at all true, hardly true, moderately true, exactly true). Examples of questions: 'It is easy for me to stick to my aims and accomplish my goals'; 'I can remain calm when facing difficulties because I can rely on my coping abilities.' It is based on the self-efficacy theory (Bandura, 1997) which postulates that people's judgments about their own capabilities determine the degree to which they will actually execute a course of actions to attain a desired goal.

Evaluative Questionnaire

Participants from both conditions—MI and FIT delivered by the video robot—gave their feedback electronically and anonymously, responding to open questions of the evaluative questionnaire.

The evaluative questionnaire consisted of 18 open questions developed for this specific study. It interrogated about the experience with the video robot and engagement with the intervention. The questions revolved around the exchange with the video robot, e.g., 'How was your interaction with the robot?'; self-awareness during the intervention, e.g., 'How did you feel about hearing yourself talk about your goals out loud?'; impact of the intervention on motivation, confidence and strategies to act, e.g., 'To what extend did the interview strengthen your desire to exercise more?'; visualisation techniques learned, e.g., 'To what extend did the interview help you to visualise how you would achieve your goal?'; further use or recommendation of the intervention; best and worst aspects of the intervention; criticisms and suggestions for improvements; and the impact of the intervention on their physical activity levels after the program.

Procedure

The intervention comprised two sessions administered in the lab with two weeks of interval between them.

In session I, participants from all three groups filled out an electronic IPAQ. After it, participants from MI and FIT groups underwent the robotic intervention.

In session II, participants from MI and FIT groups filled out electronically the IPAQ, GMS-PA, self-efficacy, and evaluative questionnaire. Participants from the control group filled the IPAQ electronically followed by the MI robotic video interview.

Setting

Participants underwent the video robotic intervention on a computer screen in one of our psychology labs. The questionnaires were filled electronically and the videos were played by Microsoft PowerPoint in full screen mode.

Data analysis

IPAQ

The metabolic equivalent task (MET) scores (minutes per week) were calculated using the formulas provided by IPAQ developers ('International Physical Activity Questionnaire', 2002). A MET score was calculated for the following domains (1) Sitting, (2) Walking, (3) Moderate-intensity PA, (4) Vigorous-intensity PA. The MET score was also calculated for all the categories on the IPAQ, the followed activities: (1) Work MET score; (2) Transport MET score; (3) Domestic and Garden MET score; (4) Leisure MET score. A total MET was generated accounting for all activities and domains.

The MET data were not normally distributed, a log transformation was executed to normalise the MET data scores prior to a 3 x 2 ANOVA with condition (MI video robot, FIT video robot, and controls) and time (week 0 and week 2) as factors.

GMS-PA

A global mean score (from zero to ten) for goal motivation was calculated which considered the complete set of questions. A one-way ANOVA compared the effect of condition on goal motivation two weeks after the first session.

Self-efficacy

The responses of each participant was added, generating a total sum score ranging from 10 and 40 points. A one-way ANOVA was conducted to compare the effect of MI and FIT in relation to a control group in self-efficacy two weeks after the first session.

Thematic Content analysis

The thematic analysis followed the same methodology as studies 1 and 2.

A content analysis was executed in order to classify the data regarding its thematic specificities with a coding system for the responses to the evaluative questionnaire. The Boyatizis's (1998) three-step method was employed which includes (1) sampling and design, (2) developing themes and codes, and (3) validating and using the codes.

Sampling

The complete set of responses from participants' written evaluation in the MI (29) and FIT group (31) were selected with a total of 60 respondents, each for 18 questions.

Coding scheme

The coding scheme was developed after inspection of the thematic components explored by the participants with a hierarchical relationship established. We considered Boyatizis's (1998) steps for this development: (1) generating a code, (2) reviewing and revising the code, (3) determining the reliability of the code.

The first draft of potential coding was generated based on the participants' evaluation and further analysis produced a specific set of themes and subthemes.

Coding application and reliability test

Two samples of unit of analysis were provided for two different raters. Each rater applied the coding scheme to the units, marking whether each of the themes and subthemes were mentioned or not by the participant. The inter-rater reliability was calculated.

Results

Quantitative outcome on PA, motivation, and self-efficacy

IPAQ

A total of 78 participants were considered in this analysis (Control=24, MI=25, and FIT=29). Eight did not fill the questionnaire properly, giving implausible numbers or greater than 24 hours for a daily estimate, being excluded from the final sample. A natural logarithmic transformation was computed to normalise the data.

Table 6.1. IPAQ log-transformed global means for all conditions (Control, MI, and FIT).

Group/Interval	**Week 1**		**Week 2**	
	Mean	**SD**	**Mean**	**SD**
Control	8.42	0.91	8.24	0.81
MI	8.26	1.16	8.38	1.16
FIT	8.42	1.17	8.39	0.79

There was no main effect of intervention type for the global score, $F(2, 75) = 0.79$, $p = .924$. There was no main effect of intervention type on any subset (work domain; active transportation domain; domestic and garden domain; leisure-time domain; sitting time and total walking time); $F<1$ for all. There was no main effect of intervention type of moderate and vigorous physical activities.

GMS-PA

All 86 participants were considered in this analysis (Control = 27, MI = 28, and FIT = 31). MI (M = 6.16, SD = 2.01) and FIT (M = 6.20, SD = 1.96) participants reported higher levels of goal motivation than the control group (M = 5.36, SD = 1.71). Although the main effect of intervention type was numerically higher, the effect of condition was not statistically significant, $F(2, 83) = 1.73$, $p = .184$.

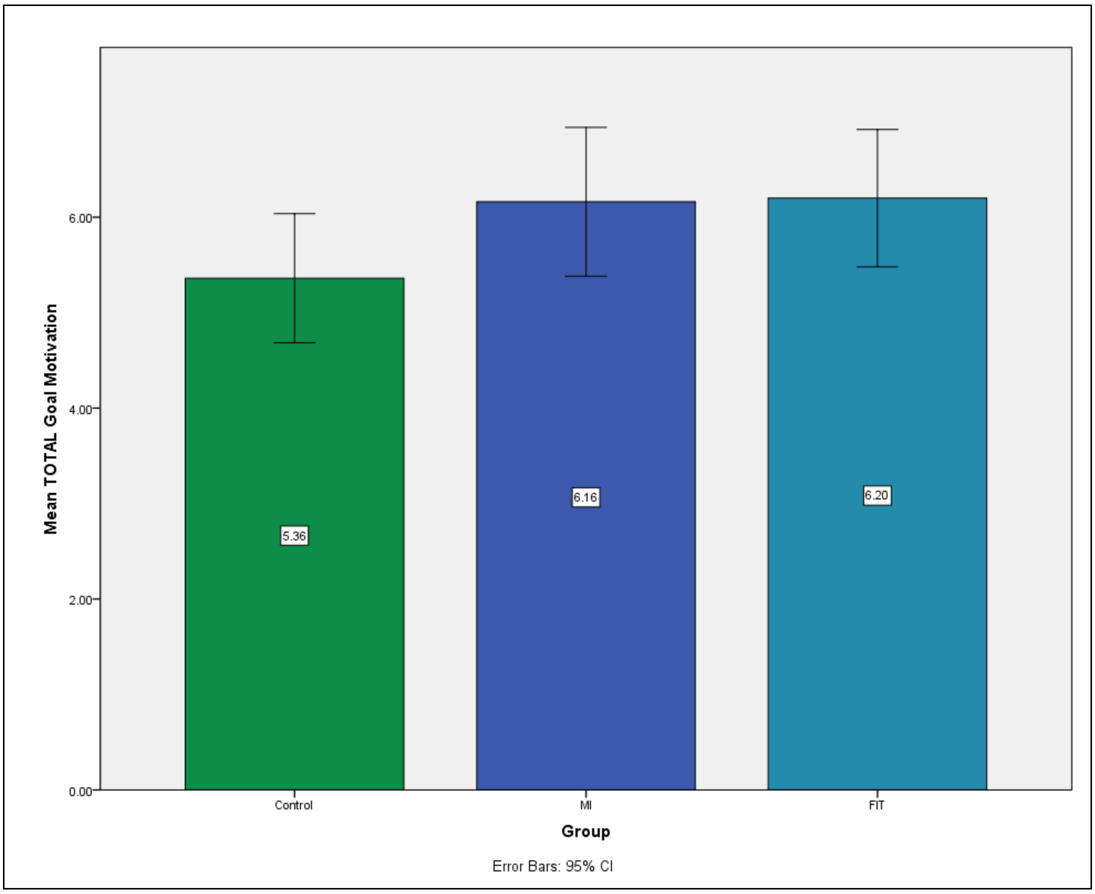


Figure 6.2. Goal motivation scale means for the three groups.

The main effect of intervention type was not statistically significant even though the means were numerically higher for MI and FIT compared with controls, GMS-PAS, $F(2, 83) = 2.05$, $p = .136$. MI (M = 6.55, SD = 1.81) and FIT (M = 6.50, SD = 1.76) participants reported higher levels of goal motivation than the control group (M = 5.67, SD = 1.85).

Self-efficacy

All 86 participants were considered in this analysis (Control = 27, MI = 28, and FIT = 31, and) for the total sum score for self-efficacy. Control group (M = 31.07, SD = 3.47), MI (M = 31.07, SD = 5.12), and FIT (M = 30.71, SD = 3.54) and the reported almost identical means. Therefore the main effect of intervention type was not significant, $F(2, 83) = .08$, $p = .925$.

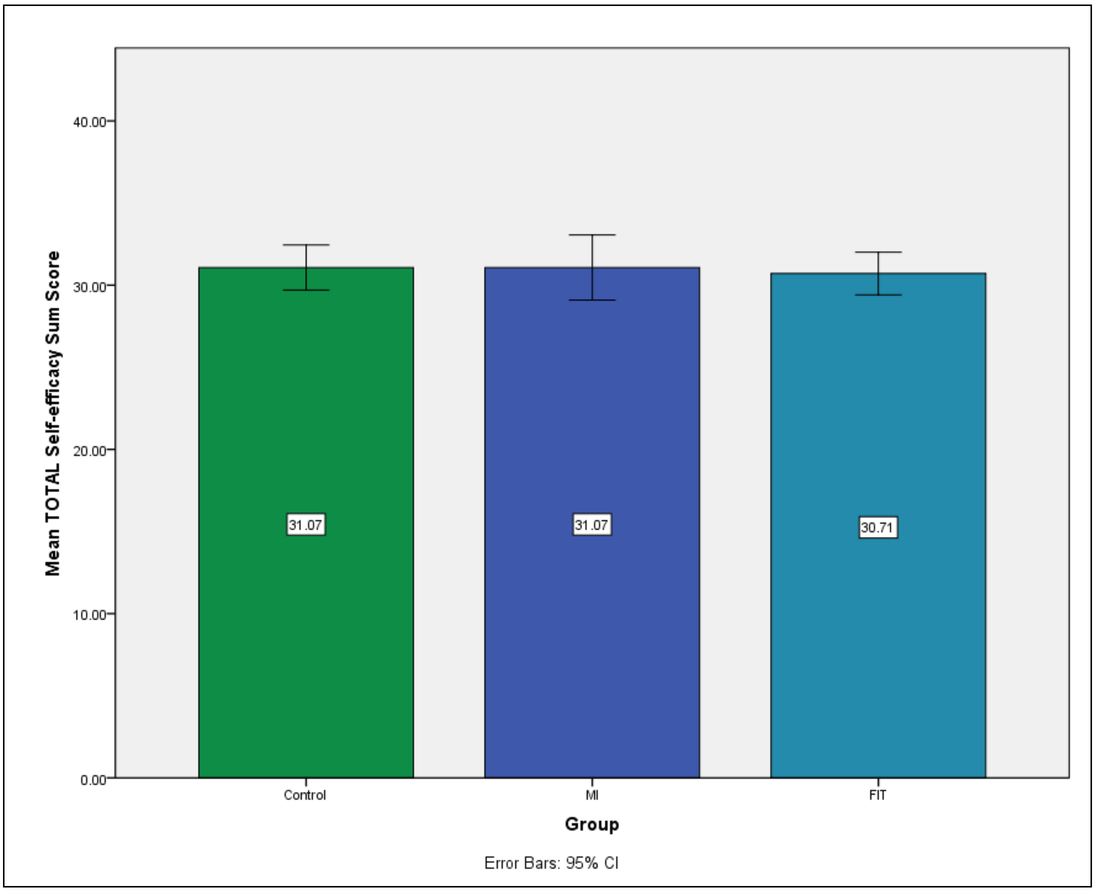


Figure 6.3. Self-efficacy sum score means for the three groups.

Qualitative robotic coach evaluation study

Table 6.2 depicts the series of themes and subthemes developed.

Hierarchy	Themes and sub-themes
1	**Connection/engagement with the robot**
1.1	Negative
1.2	Neutral
1.3	Positive
2	**Listening to oneself**
2.1	Negative

2.2	Neutral
2.3	Positive
3	**Facilitation of planning/visualization**
3.1	Negative
3.2	Neutral
3.3	Positive
4	**Impact on confidence/motivation/strategies for change**
4.1	Negative
4.2	Neutral
4.3	Positive
5	**Impact on physical activity**
5.1	Negative
5.2	Neutral
5.3	Positive
6	**Recommendation/use of the robotic coach in the future**
6.1	Negative
6.2	Neutral
6.3	Positive
7	**Overall evaluation**
7.1	Strengths of the intervention
7.2	Criticism/suggestions for improvement

Reliability test

The inter-rater reliabilities for the two units (IU1009 and YA1512) were both 90%. The coding scheme was assumed reliable.

Participants' evaluation

Program evaluation

Participants from both conditions had a similar experience in the majority of the topics but slightly distinct in one subtopic—facilitation of planning/visualization.

Connection/engagement with the robot

Participants in both groups found the interaction with the robot enjoyable. Many used words as 'interesting', 'surprising', 'interactive', or 'pleasant'. Most considered the interaction engaging or moderately engaging. Some commented that the robot's voice was annoying or hard to understand. Others found the interaction silly, awkward, or boring. Some of the participants who initially had a difficulty in interacting with the robot could overcome the initial problematic phase and engage with the robot subsequently.

> *Good substitute for a person, although felt a little uncomfortable talking to a robot. (MU2504). FIT*

> *Very engaging, the robot was very powerful and really grabbed my attention. His speech was very strong and again, powerful. (IA0905). FIT*

> *Verbal, honest and intriguing. It was just like speaking to someone without them giving their opinion, but they would allow you to reach your answer on your own. (SD1207). MI*

> *Easy to get into though, and engage. I think I engaged a little too well as I ran over time by 15 minutes! Felt comfortable to interact as asked after some slight initial shyness. (EN1801). FIT*

> *It was a little uncanny at first, as it was not responsive but followed the script, but after a couple of minutes, it became very enjoyable. (NA1701). MI*

> *I found it interesting and was surprised at how influential he was and how hard I listened to the robot. (IA0905). FIT*

It felt like I was speaking out my thoughts to help someone who was in the exact situation as me. (SD1207). MI

I found it strange and unnatural interacting with the robot (TA0910). FIT

Listening to oneself

Participants from both conditions had a comparable experience of listening to themselves speaking about their behaviours, motivations, and goals out loud. Listening to themselves was reported to have a mostly positive effect. The experience of talking out loud made the participants think further about their status and future plans; it made them feel more 'real'. They cited expressions as 'being self-motivational', 'helpful', 'personal', or 'feeling encouraged'. For these participants who evaluated this intervention characteristic as positive, it seemed therapeutic to listen to themselves. Some mentioned that it was uneasy to listen to their voice and became self-conscious.

Talking aloud with the robot helped me feel more confident about what I had said I was going to do. (TA0910). FIT

It was different saying it out loud than in my head, more motivational about what I want. (BI3010). FIT

It was weird, it is unusual for me to talk about these things and I found strange to remotely try to verbally express it, but it gave me more focus afterwards, like some mindfulness meditation. (NA1701). MI

It was a strange thing to do as it's not something you'd normally do but I think talking aloud allows you to hear how realistic what you are saying is. (LO2011). FIT

I felt it was really important because it was a verbal reinforcement of what I wanted to achieve rather than just a thought that could be dismissed. Somehow it felt like I had made an agreement with myself. (YA1512). MI

Sometimes could be really important to discuss your behaviour by yourself without external judger. (SU0101). FIT

I don't think it would have been as successful if I didn't. Saying it out loud made it a little realer and like I had to tackle it rather than just avoid it. (EN1801). FIT

I think it was more important it comes more real once you have said it out loud and enables you to process it further in your brain, made me more confident and defined my goals. (AL2505). FIT

I don't think it was that necessary - I feel that I would have had the same affect just being asked to think about the answers instead of saying them out loud. (YH0705). MI

I don't like the sound of my voice so it felt uncomfortable (LU0511). MI

Facilitation of planning/visualization

This is one category in which the two conditions partially differed. While the participants on the MI condition mostly mentioned that they improved their planning, FIT participants reported that visualization was the main outcome. Some participants from the MI group mentioned that the questions also led to some visualization and some participants from the FIT group had problems in reaching vividness in their visualizations.

> *This was a good bit as I could think through how I would actually do it and talk to myself about this so I had a clear plan and could see myself getting ready to go to the gym (YA1512). MI*

> *I was very shocked at how vivid my imagination could actually be (TL0901). FIT*

> *I don't think it helped visualise it. (AI2402). MI*

> *It helped to visualise more than other methods would have, help to give me a clear image. (IE1612). FIT*

> *It kinda walked through the whole thing, so it inadvertently prompted me to create a plan. (NA1701). MI*

> *I found it very difficult to provide sufficient vividness to the images. (OE2802). FIT*

> *I had a clear visualisation of my goal and it made it seem more reasonable that I would be able to achieve my goal. (TA0910). FIT*

I think it helped me visualise it a lot, this was done through the questions that were asked and the occasional repetition. (EA1209). MI

Impact on confidence/motivation/strategies for change

Participants from both groups reported that the intervention helped them to motivate themselves and create strategies to put their plans in action. Many participants reported strengthening their desires or feeling more eager to exercise. Others described how they developed strategies to exercise more. Some felt more confident about increasing their physical activity levels while others did not. Others reported that the intervention had a moderate or low impact on their motivation. A few claimed that their motivation was unchanged.

After the interview I felt that I needed to put in place the physical changes that I talked about because my reasoning made sense and changed my perspective of my activity levels. (LL0402). MI

I felt more confident that I could exercise more and I wanted to because I thought about a time I succeeded in the past and thinking about starting and feeling good about it is good motivation. (AL2505). FIT

The interview broke it down to make it more manageable so as to not see obstacles so much as obstacles, more just like a step in a series of steps towards a goal. (EN1801). FIT

The interview made me think about all different angles of setting my goal and how I could achieve it. therefore it helped to have ways of sticking to my strategy which I didn't have before. so it helped a lot. (EA1209). MI

It gave me a sense that I wasn't just keeping my plans for myself but because I had told the robot what I intended and I did not wish to be neglectful of that. (LY2305). MI

It increased motivation for a short time. I left the interview wanting to do exercise, however, the effects wore off a few days later. (BE2903). FIT

It felt repetitive at the time but it did make my intentions very clear and thought out in my mind. Being able to verbalize my plans, even to a robot, made me feel responsible for carrying out those plans. The robot was easy to understand and asked some insightful questions. (LY2305). MI

I had little motivation before the interview and once it was completed I had a greater desire to complete the tasks I had set myself. (TA0910). FIT

It helped me plan what the inevitable obstacles were going to be and have a plan for heading them off so it didn't sabotage my plans for exercise. (YA1512). MI

It didn't help me massively I think the strategies were okay but involved a lot of concentration and motivation to use the strategies. (IE1612). FIT

Impact on physical activity

Most participants reported that they improved their physical activity levels by booking gym classes, going swimming, playing Pokemon Go, cycling, running or walking. Others claimed that they improved the intensity or frequency of the exercises they were already doing. Some found it hard to engage in physical activity due to life circumstances as the weather, social engagement, school work, or other commitments. Others mentioned that they did not improve their physical activity levels.

I did an extra couple classes at the gym and booked in for some I hadn't tried before. (YA1512). MI

I walked more and spent more time outside as opposed to sitting down. (IE1612). FIT

Since I had the interview, I have gone swimming 5 times, bearing in mind I hadn't gone swimming for 2 years prior to this. I increased the general amount of time I was on my feet and went for walks (although Pokemon Go helped). (TL0901). FIT

For the first week, I did because I went to some exercise classes at the gym. Unfortunately during the second week, I was ill so didn't do as much. (YH0705). MI

I didn't improve my physical activity after the robotic interview but I think this was because I didn't use the visualise techniques after the interview and I was unwell and went home for a few days so my routine changed, however if my routine was as normal and I thought about visualising exercise whilst brushing my teeth like I told the robot I would I think my physical activity would have increased. (AL2505). FIT

Recommendation/use of the robotic coach in the future

Participants from both conditions reported similar thoughts about recommending or using the robotic coach again. Many would recommend the intervention but emphasize that it would depend for which person. They also claimed that they would recommend the intervention to a friend under certain conditions (e.g., to someone with no motivation' or 'if they had an objective') while others would not recommend to a friend. For their future use of the intervention if offered, most would undergo it again, some were unsure about engaging with it again, and a few would not try it again.

It may be beneficial for some people due to the potential flexibility of the meetings. (NM1404). FIT

I would try it again, and I would like to do it on a more regular basis. (BE2903). FIT

Definitely [I would recommend it]. Especially to those trying to stick to a gym routine, or to those dieting, or trying to lose weight. It would help them realise that they know what they have to do to *achieve their goal, without getting someone else to say it to them. (SD1207). MI*

The experience was good, made me think about the ways in which I can improve and what I would benefit from it. It made me want to do more physical activities more often. I would recommend to friends who need the encouragement. (EA1209). MI

Maybe it might help someone else, but personally didn't work for me. (GL0203). FIT

I feel as if it could help motivation in lots of areas, if a programmed was set up and designed for weekly sessions. (BE2903). FIT

I'd recommend it to children but not adults. (NA0312). FIT

I would prefer a more realistic character. (AA3011). MI

Overall evaluation

Both conditions had a similar view on the program and provided insights about the pros and cons of the intervention and how it could be improved.

Strengths of the intervention

Among the strengths mentioned by both groups were: speaking out loud; planning; spotting difficulties and working around them; trying something new and engaging with an innovative digital experience; thinking about one's own behaviour; the motivational aspect of it; interacting with a non-judgemental robot. Some participants in the FIT condition claimed often that the visualization techniques were the best feature of the program.

> *This was the most beneficial part of the entire process. It taught me well and I used this to help me outside of the research room. (TL0901). FIT*

> *The best aspect of it for me was spotting the difficulties that would arise and already planning around so that when they came up for me I knew what I would do. It also helped me to visualise the benefits which helped me to stay focused. (YA1512). MI*

> *Being able to reflect on my exercise with no one in the room, as it's always that fear when talking to a researcher of whether they will judge participants, especially with me being a coach potato. (TL0901). FIT*

> *Communicating with the robot, rather than a human; didn't feel that anxious, which made me feel better in engaging with the interview. (RE3110). FIT*

> *It was very interesting as it was interactive but also digital. The whole setup was mesmerizing at first, so my attention could easily be focused on it. (NA1701). MI*

> *You can be more frank, open and honest with the robot which lessens the fear of ridicule which is very much attached to exercise in my mind. (LY2305). MI*

I was talking to a robot I didn't feel embarrassed or ashamed to say anything as I know the robot wouldn't have judged me at all. (IU1009). FIT

I found the interview very interesting. It made me realise just how much we could push our self to do something when speaking about it out loud. I did want to go back to the gym after that, but due to my schedule being busy, I wasn't able to achieve that goal. But the robotic interview kept playing in the back of mind; as it made me think of how useful it would be for someone who was a trying to stick to a certain routine, to gain mass or lose weight, and made me realise that I could be trying harder than I already am. Overall it was a good eye opener. (SD1207). MI

Criticism/Suggestions for improvement

Participants from both groups reported that among the worst aspects of the intervention were: repetitive questions; not personalized responses; robot's voice; talking to a machine; artificiality; clicking the button to go to the next question; not being a human. Suggestions for improvement varied. Participants suggested tailored answers; making the robot human; changing the robot's voice; interacting with a real robot; using virtual reality; shortening the interview; or that it could be downloaded as an app. Some suggested that having a more frequent interaction with the robot would be beneficial.

I enjoyed the experience, however, I felt it would be more beneficial, having more than one interview - potentially having *regular interviews weekly would had caused me to think about doing more physical activity. (BE2903). FIT*

I feel as if it could help motivation in lots of areas, if a program was set up and designed for weekly sessions. (BE2903). FIT

[The worst aspect was] not getting a good flow of questions in relation to my answer. (SD1207). MI

With talking to a screen and a pre-recorded robot it is obviously very artificial, and sometimes that would compromise how serious I would take it. (TL0901). FIT

It followed a script, and therefore non-responsive, which was kind of like reminding me of Chaplin's feeding machine (in a good way), but was still a great experience. (NA1701). MI

Some of the answers given by the robot were repetitive. (UA1005). FIT

I know this may create more work for the one making the interview happen; but if there were multiple directions the robot could interpret an answer through the user speaking and then choosing an answer closest to what they said. This would help tailor it to multiple people. (SD1207). MI

An actual robot would be amazing, although easier said than done. (TL0901). FIT

A more human aspect to it. Use a real person or a robot which isn't just a recording. (OE2802). FIT

Create different narratives that could be taken by answering some questions, like those old role-playing books made for the youth, where you had to make decisions which affected the story. (NA1701). MI

Maybe if it was a person on the screen instead of a robot then it could improve the results. (TA0910). FIT

I talked to the robot like I was talking to a normal person, I felt I could say more than I would be able to if I were talking to an actual person. The only downfall is the robot could not respond in a critical and useful way. (SA2311) FIT

Discussion

MI has been successful in face-to-face for a range of behaviours, including physical activity (Bennett et al., 2007). FIT outdid MI for weight loss in face-to-face traditional delivery (Solbrig et al., 2018). We expected that both MI and FIT would have an impact on physical activity but that FIT would be superior in prompting behaviour change. Against our predictions, there was no advantage in efficacy of a video coach delivering either MI or FIT on participants' physical activity levels, goal motivation, and self-efficacy compared to a control group. The acceptability of the video robotic MI and FIT intervention was also investigated with a qualitative evaluation from participants, in which they reported feeling engaged by the video robot but still missed a personalised response as in studies 1 and 2. The translation of MI and FIT to this robotic delivery into technology might have impaired the potential of these counselling techniques. Another possible factor that might have influenced the results is the study design employed.

The physical activity levels, measured by IPAQ did not show any significant difference between MI, FIT, and the control group. The IPAQ was completed two weeks after the intervention with participants reporting only the latest week of physical activity. In the qualitative component of this study, many participants from both MI and FIT group reported that the initial motivational kick did not have lasting effects. This ephemeral motivational effect could be one explanation of the lack of difference in physical activity levels between interventional groups measured with IPAQ two weeks after the intervention. With this study design, we were not able to capture quantitative differences in the first week after the intervention, but only in the subsequent week.

There was a problem in the physical activity measurement. We chose the IPAQ for being a well-established low-cost form of assessment, but found that participants had difficulties in understanding how they should respond. Eight individuals had to be excluded from the analysis (e.g., participants reporting numbers greater than 24 hours for a daily report, probably assuming it was a weekly entry). Other researchers have also found that participants have difficulty understanding the IPAQ questions, for example having difficulties in making distinctions between the different exercise domains, leading to duplicated answers (e.g., Hallal et al., 2010). A direct measurement could possibly lead to more reliable results, but there are also limitations of monitoring physical activity. For instance, a pedometer does not capture activities as swimming and an accelerometer does not measure upper body movement.

In the qualitative report, participants commented on the relationship between motivation and taking action upon behaviours. Many participants reported an increased motivation, but that their motivational boost was short lived. Several participants suggested that the intervention should be longitudinal with frequent motivational training. Remote deliveries with greater contact lead to more positive outcomes (Vandelanotte, Spathonis, Eakin, & Owen, 2007), with follow-up prompts being important to achieve physical activity maintenance (Fjeldsoe et al., 2011). A periodic encounter with the video robot could potentially sustain their motivation as opposed to the faded effect of this single encounter.

The FIT and MI-based robotic interventions did not affect self-efficacy for increasing physical activity. With hindsight, the assessment tool was not ideal. Most participants reported in the qualitative component that the MI and FIT intervention helped them feel more confident about achieving their physical activity goals. However, the general self-efficacy scale employs questions about self-efficacy in a more permanent sense (e.g., 'I can solve my problems if I invest the necessary effort') (Schwarzer & Jerusalem, 1995) rather than a temporary domain-specific estimate. For future investigation of differences in self-efficacy directly attached to this MI and FIT robotic intervention to motivate physical activity, it would be helpful to use a more precise measurement as, for instance, the exercise self-efficacy scale (McAuley, 1993) which involves time-framed questions (e.g., 'I am able to continue to exercise three times per week at moderate intensity, for 40+ minutes without quitting for the next week ') ('The Exercise Self-Efficacy Scale', 1993).

Participants' reports in the qualitative component of this study help to explain the unaltered behaviour measured quantitatively. Listening to themselves speaking out loud about their goals and motivations was, as in Study 1 and 2, mostly positively appraised, however, the strict set of pre-recorded questions broke the perception of a personal and flowing conversation. Although we had considered testing tailored responses, we decided to retain the simpler interface so we could compare FIT with the version of MI delivered by the video-counsellor in Study 1 and robot in Study 2. Further studies could tackle the reported impersonality of the intervention by tailoring it.

The non-judgemental aspect of the robot that appeared in Study 2 was confirmed in this current study even with a video-screened robot coach. This positive effect of a non-prejudiced machine in this virtual-delivered intervention shows that a robotic approach can also be applied remotely, minimizing the labour costs related to a robotic face-to-face delivery, keeping this helpful aspect. Previous research has found that, although children interacted more with an embodied robot in terms of increased eye contact and emotional reaction, but both physical and screened versions engaged them equally in a motor exercise game that invited them to perform specific movements with their arms (Fridin & Belokopytov, 2014). Our study shows similar results with the video robot having comparable reported benefits as the physical robot in Study 2. Participants also mentioned that they felt more relaxed and less anxious than if they were interacting with a real person. It has been shown that people prefer to divulge negative or sensitive information to a non-human than a human being (e.g., Gerbert et al., 1999; Caldwell & Jan, 2012; Pickard et al., 2016). This interpersonal perspective could offer benefits in a range of psychological applications and be especially profitable for participants with specific emotional or cognitive conditions (e.g., social anxiety) and should be further investigated.

This study elicited similar feedback from participants than Study 1 and 2, positively appraising the space to talk about their goals and behaviour, criticizing the impersonality of the virtual coach, or suggesting a greater interaction. Some of the suggestions given by participants were applied in other of our studies or initially planned. Some suggested that a human should be used instead of a robot without knowing that we had already developed a video human coach (Study 1) and a 2D-hologram like human coach (Study 4). Other proposal was to interact with a real robot which was done in Study 2. A participant proposed that it would be good if one could download it as a mobile software application on the phone, which grabbed the core idea of the project that is to make the intervention available remotely for a larger group of people. This would be an interesting avenue for future research, and would raise questions about the extent to which people might form a 'relationship' with a robot that they interacted with frequently.

FIT outdid MI in a face-to-face delivery for weight loss (Solbrig et al., 2018) as well as FIT seemed more prone to a remote delivery. The expected advantage of FIT was not confirmed in our automated intervention. Both automated robotic MI and FIT also did not have an impact on behaviour change compared with the control group, suggesting that the remote delivery might have impaired the potential of these counselling techniques. One reason might be that our study design and outcome measures were not sensitive enough to detect change. Other alternative is that participants' motivation was low from the beginning and that increasing it a little bit was not enough for them to start exercising more. Even though there was no difference in behaviour change of our automated MI and FIT, the qualitative component of this study revealed that a video robot could be as acceptable as a physical robot. Participants reported that both MI and FIT were helpful but that the motivational gain faded quickly. Two other candidates for the null results are the impersonality of our robotic intervention that might have hurt the potential for its effectiveness, and the study design that failed to capture behaviour change right after the program. Many questions remain of how this screened robotic intervention can be helpful for behaviour change, but the non-judgemental reported aspect of it might be a cheap-remote tool to gather sensitive information that users would not reveal to a human being.

Chapter 7: Study 4 - A minimal Functional Imagery Training delivered by a 2D hologram against a screened video coach

Introduction

We have developed in our previous studies (1 and 2) automated MI employing a human video coach and a face-to-face robot. One of the problematics of our dynamic automated MI detected in Study 1 and 2, cited in Study 3, was the lack of personalized feedback to the participants' particular reponses. Automating MI poses a series of challenges regarding the translation of this counselling method's conversational essence into technology. FIT, as cited previously, builds on MI with visualization exercises (Kavanagh et al., 2014), based on the EI theory (May et al., 2012), and has been shown more effective than MI in weight loss (Solbrig et al., 2018). An intervention where the work happens in people's minds rather than through speaking aloud might also adapt more easily to tech-based deliery. Study 3 and 4 were designed simultanously for logistical and time-constraint reasons, therefore, they had an analogous study design, with the application of the same set of questionnaires and interval. For this reason, Study 4 does not reflect any study design improvement in relation to Study 3, but tackled issues raised in Study 1 and 2 with a different set of solutions.

In Study 3, we utilised a FIT script with mental imagery exercises that involved MI questions in a video robotic intervention, but that also depended on verbal exchange. Even though participants positively appraised speaking outloud for their goal setting and motivation, the lack of congruent verbal response by the virtual coach was negatively evaluated, which was also the main problem raised in Study 1 and 2. The current study employed a minimal FIT script that used the mental imagery exercises but ommited the dialogue. There were two reasons for doing this. One is that removing the dialogue potentially alters the participant's expectation of a personalised response because they are engaging with it silently. Removing the dialogue carries a substantial risk because it removes an aspect that was positively appraised in the previous studies, namely the power of speaking one's goals and plans aloud. However, there was another reason for removing the dialogue, which was to test a motivational intervention using a 2D projection of a video-counsellor. As explained below, using technology in this novel way would be much easier if there was no need for the participant to advance to the next question and if there was no uncertainty about how long the video counsellor needed to 'listen' while the participants spoke their answer.

Companies as Tensator have been commercialising a two-dimensional full body projection advertised as virtual assistants, which they claim to be ten times more effective influencing behaviour change compared to average signs (Tensator, n.d.). To our knowledge, only one group of researchers have used a similar 2D holographic set-up as cited on Chapter 2, but in a classroom environment. Luévano and collegues (2015) detected that 65% of students reported paying more attention a professor projected in a 2D-hologram than a telepresential robot. Embodied virtual coaches are seen more pesuasive and perceived more positively (Li, 2015), prompt higher empathetic responses (Paiva, Leite, Boukricha, & Wachsmuth, 2017), and elicit higher interaction (Fridin & Belokopytov, 2014) than screened versions. As others have found a more positive response to a 2D projection than a screened video coach, we expected that the 2D hologram-like coach would lead to greater acceptability and effectiveness. We predicted that this 2D set-up with a human projection would be a more similar experience to a face-to-face FIT delivery, immersing the participant into a close-to-real atmosphere and enhancing the experience of a quasi-human interaction. A human's voice could pose an advantage in relation to a robot's speech as in Study 2 participants reported that it was sometimes hard to understand the humanoid and they found its voice quirky. As there would be no verbal responses by the participants opposed to MI in Study 1, 2 and 3 and FIT in Study 3, we predicted that the non-judgemental advantage in relation to the robot be less relevant as there would be lower anxieties in the interaction as participants would only engage mentally. A trained FIT coach could also preminently create the nuances and rythm of mental imagery exercises.

In this study, we compared a human 2D coach with the same coach reproduced in a computerized screen to investigate the effect of a presence on participants, both in relation to a control group. This study offered the possibility of investigating mental imagery exercises of FIT in isolation and examining the intervention's impact on outcomes: physical activity levels, goal motivation, and self-efficacy. As in Study 3, we expected that the FIT intervention would increase these three behaviours in relation to a control group, but that the 2D coach would have a greater impact than the screened version of it.

Methods

Participants

A total of 104 participants, recruited from the School of Psychology's pool of students and volunteers wishing to increase their physical activity levels, partook the study, randomly allocated in three conditions. 89 participants completed both sessions and were considered for analysis—30 in the (1) 2D coach group, 32 in the (2) screened video coach group, and 27 in the (3) control group with delayed treatment. Participants' ages ranged from 18 to 60. Four fifths were female and one fifth were male. Students received credit points for their courses and volunteers were paid per hour.

Materials

Functional imagery training (FIT) script

The FIT script was shortened from the previous original version in Study 3 in order to leave only the mental imagery exercises with no MI questions. As this intervention was not verbally interactive, the mental imagery exercises developed in a flowing sequence with the coach giving instructions about each visualization task. The introduction welcomed the participant and explained the purpose of the intervention. The FIT script started with a warming-up exercise explaining the basis of using all the senses in the mental imagery exercises, followed by visualization tasks about the current and ideal situation regarding the physical activity levels of the participants as well as possible obstacles faced in the process and how participants could overcome them. Below is an excerpt of the FIT script.

You've been thinking about increasing your physical activity.

Think about the downsides of your current level of activity.

Imagine a particular occasion when one of those downsides may occur.

Use all your senses to imagine the scene as vividly as you can...

What you would see, and hear, and how you would feel...

(pause)

Let's imagine that you have succeeded at becoming more active.
Think of a time when you may experience some improvements.

(pause)

Visualise where you are...

(pause)

what is happening around you...

(pause)

how your body is feeling...

(pause)

and how you feel within yourself, emotionally.

The script was structured with pauses between the instructions as seen above, giving time to the participant to delve into the visualization exercises. The script finished with a concluding statement, advice from the counsellor to keep practicing mental imagery, and a farewell message.

Developing the 2D coach and video intervention

The FIT script was recorded in a continuous single shot against a green screen background in the Plymouth University's video recording studio. Linda Solbrig, a psychology PhD researcher who is experienced in delivering FIT face-to-face and with training in acting, was the chosen video coach. In the first recording session, she trained how to read naturally from the teleprompter at the same time that the size of the font and speed of the text were adjusted to a rate that felt appropriate—a calm pace with long pauses to give space to the participants to engage with the exercises. Linda was instructed to stay still for a fixed pose as the video had to contain minimal movement—to be constantly projected into the silhouette acrylic cut-out—while presenting an empathetic and serene countenance.

After several rehearsals, a final take of the FIT script was considered for the official version with a total of about 13 minutes. In postproduction, the contrast, brightness, hue, and saturation were adjusted. For the 2D projection, the chroma key tool was utilized replacing the background with a solid black. For the computerized screened video projection, the background was converted to grey.

Figure 7.1. Illustration of the set up with a projector and life-size half-body 2D coach.

Questionnaires

International Physical Activity Questionnaire (IPAQ)

We utilized the same IPAQ long last seven days self-administered format ('International Physical Activity Questionnaire', 2002) described on the methods section of Study 3, which comprises five parts: (1) job-related physical activity; (2) transportation physical activity; (3) housework, house maintenance, and caring for family; (4) recreation, sport, and leisure-time physical activity; (5) time spent sitting. Each section requires specific information in number of days, hours, and minutes about specific engaged physical activities.

The Goal Motivation Scale for Physical Activity (GMS-PA)

We applied the same GMS-PA (Kavanagh et al., n.d.) questionnaire utilized in Study 3 constituted of two sections: (1) Strength (GMS-PAS) and (2)

Frequency (GMS-PAF). Each of the two are subdivided into intensity, imagery, and availability. Each of the questions require an answer in a scale from zero to ten. The same mechanical error described in Chapter 6 occurred with the last question of the GMS-PAS being omitted for a total of 11 questions in this section and a complete set of 12 questions in the GMS-PAS.

General Self-Efficacy questionnaire

The same general self-efficacy questionnaire (Schwarzer & Jerusalem, 1995) applied in Chapter 6 was utilized with 10 questions with a rating scale of four items (not at all true, hardly true, moderately true, exactly true).

Evaluative questionnaire

A qualitative questionnaire with 17 open questions was generated using many of the questions previously developed for Study 3 plus some new questions about mental imagery. The set of questions enquired about the participant's experience and connection with the virtual coach (e.g., 'How engaged did you find the virtual counsellor?'); the process and importance of imagining their goals (e.g., 'How did you feel about imagining your goals?'); impact of virtual counselling on their motivation and exercise (e.g., 'To what extent did the virtual counselling strengthen your desire to exercise more?'); best and worst aspects of the intervention; whether they would use again or recommend the virtual counsellor to a friend; suggestions for improvements as well as criticisms.

Procedure

The study was divided into two sessions administered in the lab, the second two weeks after the first one..

In the first session, participants from all three conditions filled out the IPAQ electronically. After the IPAQ, participants from the 2D coach and video coach condition underwent the FIT intervention.

In the second session, participants from all three conditions filled out electronically the IPAQ once more, the GMS-PA, and the self-efficacy questionnaire. Participants from the 2D coach and video coach condition responded to open questions of the qualitative questionnaire electronically.

Setting

We utilized a psychology lab called soft lab dressed as a living room for the 2D projection. This room had enough space for the set-up as the projector required a particular distance from the projector for the acrylic cut-out for the life-size upper body projection. For the computerized screened version, participants underwent the intervention in a standard psychology lab room, where the video was reproduced from a media player in full screen mode. The computerized questionnaires were also administered in a standard lab room. Participants from the control group underwent a FIT video coach session after completing the IPAQ.

Data analysis

IPAQ

The data was processed accordingly to the IPAQ guidelines ('International Physical Activity Questionnaire', 2002), using the provided formulas to calculate the metabolic equivalent task (MET) scores (minutes per week). The following total MET scores were calculated: (1) Sitting, (2) Walking, (3) Moderate Intensity PA, (4) Vigorous-intensity PA. The MET scores for the following activities were also calculated: (1) Work MET score; (2) Transport MET score; (3) Domestic and Garden MET score; (4) Leisure MET score. A total MET score was generated accounting for all activities and domains.

The data was detected to be not normally distributed in all domains and for the total score. For this reason, a log transformation was executed to normalise the MET data scores followed by a 3 x 2 ANOVA with condition (2D coach, video coach, and controls) and time (week 0 and week 2) as factors.

GMS-PA

The total score of each section—GMS-PAS and GMS-PAF—was calculated as well as for each of the subsections (intensity, imagery, and availability). A total goal motivation score was calculated.

A one-way ANOVA was computed to compared the effect of the 2D coach and video coach both delivering FIT in relation to a control group in goal motivation two weeks after the first session.

Self-efficacy

The sum of responses of each participant was calculated, generating a global score ranging from 10 to 40 points.

A one-way ANOVA was conducted to compare the effect of the 2D coach and video coach both delivering FIT in relation to a control group in self-efficacy two weeks after the first session.

Content analysis

A content analysis was executed, generating a coding system based on the thematic content of the participants' responses to the qualitative questionnaire. We utilized Boyatizis's (1998) three-step method consisting of (1) sampling and design, (2) developing themes and codes, and (3) validating the codes.

Sampling

The whole set of the participants' responses from the 2D and video coach conditions to the qualitative questionnaire was considered with a total of 62 respondents (2D coach=30; video coach=32). Each unit of analysis consisted of the individual responses for the complete set of questions.

Coding scheme

The coding scheme was generated after intense examination into the participants' responses. The codes were developed based on Boyatzis's (1998) steps: (1) generating a code, (2) reviewing and revisiting the code, (3) determining the reliability of the code.

A preliminary list of themes emerged with subthemes followed by a refinement of the codes. A final coding scheme was developed.

Coding application and reliability test

The coding scheme was rated by two independent coders. Two units of analysis were considered as samples for the ratings. Each coder independently rated each unit of analysis considering whether each theme or subtheme was present or not in each section. The results were compared and the inter-rater reliability calculated. Final adjustments of the coding scheme were applied.

Results

Quantitative outcome on PA, motivation, and self-efficacy

IPAQ

A total of 68 participants were considered in this analysis (2D coach = 21, Video coach = 23, and Control=24). Eighteen did not fill the questionnaire properly, giving implausible numbers or greater than 24 hours for a daily estimate, being excluded from the final sample. A natural logarithmic transformation was computed to normalise the data.

Table 7.1. IPAQ log-transformed global means for all conditions (Control, 2D, and video coach).

Group/Interval	**Week 1**		**Week 2**	
	Mean	**SD**	**Mean**	**SD**
Control	7.81	1.12	8.10	0.98
2D	8.20	1.00	8.25	0.98
video	7.98	1.10	8.19	0.96

There was no main effect of intervention type for the global score, $F(2, 65) = 0.47$, $p = .627$. There was no main effect of intervention type on any subset (work domain; active transportation domain; domestic and garden domain; leisure-time domain; sitting time and total walking time); F<1 for all. There was no main effect of intervention type of moderate and vigorous physical activities.

GMS-PA

A total of 89 participants were included in this analysis (2D coach=30, video coach=32, control=27). For the global score of goal motivation, participants on the 2D coach (*M* = 6.16, *SD* = 1.53) and video coach group (*M* = 6.17, *SD* = 1.92) reported higher scores than the control group (*M* = 5.58, *SD* = 1.98). However, the main effect of intervention type was not significant, $F(2, 86) = .99$, $p = .375$.

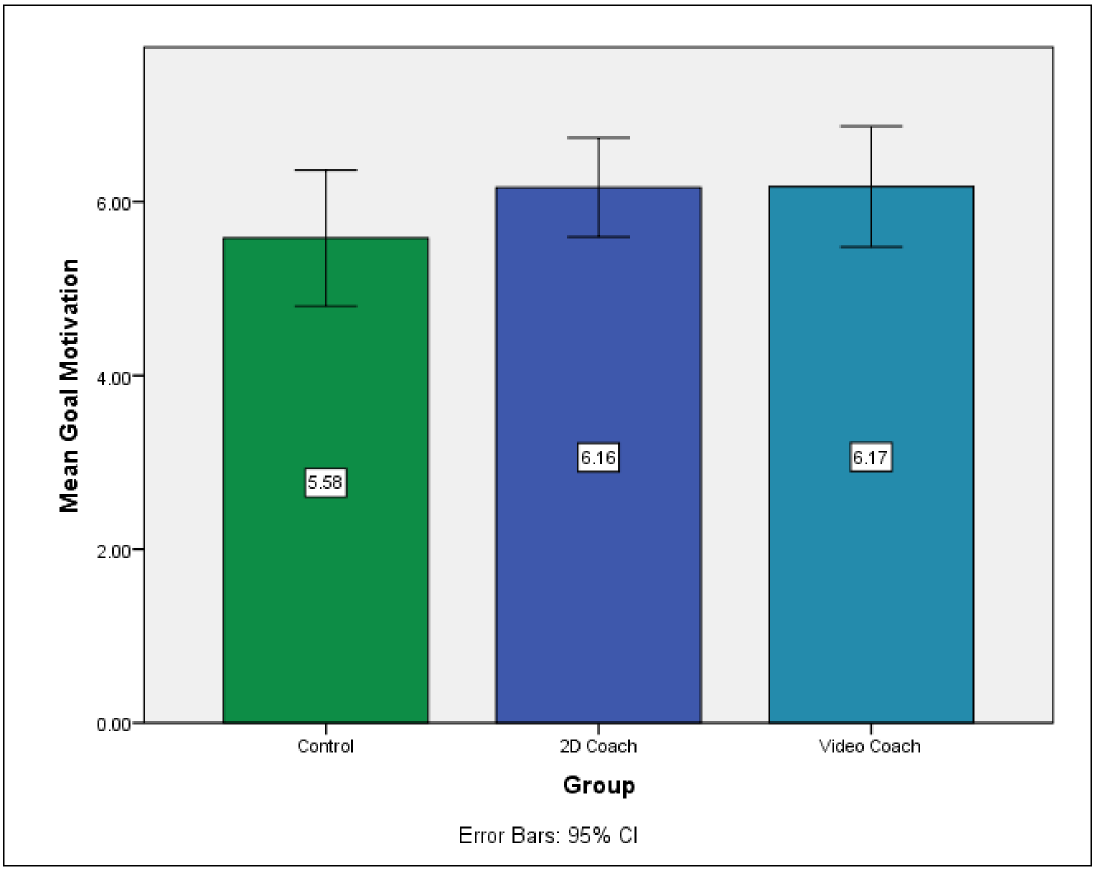


Figure 7.2. Goal motivation scale means for the three groups.

Self-efficacy

89 participants were included in this analysis (2D coach=30, video coach=32, control=27) for the total sum score for self-efficacy. Control (*M* =

29.11, SD = 4.01), 2D coach (M = 29.37, SD = 3.19), video coach (M = 30.03, SD = 3.31 reported very similar values. Thus the main effect of intervention type was not significant, F(2, 86) = .54, p = .582.

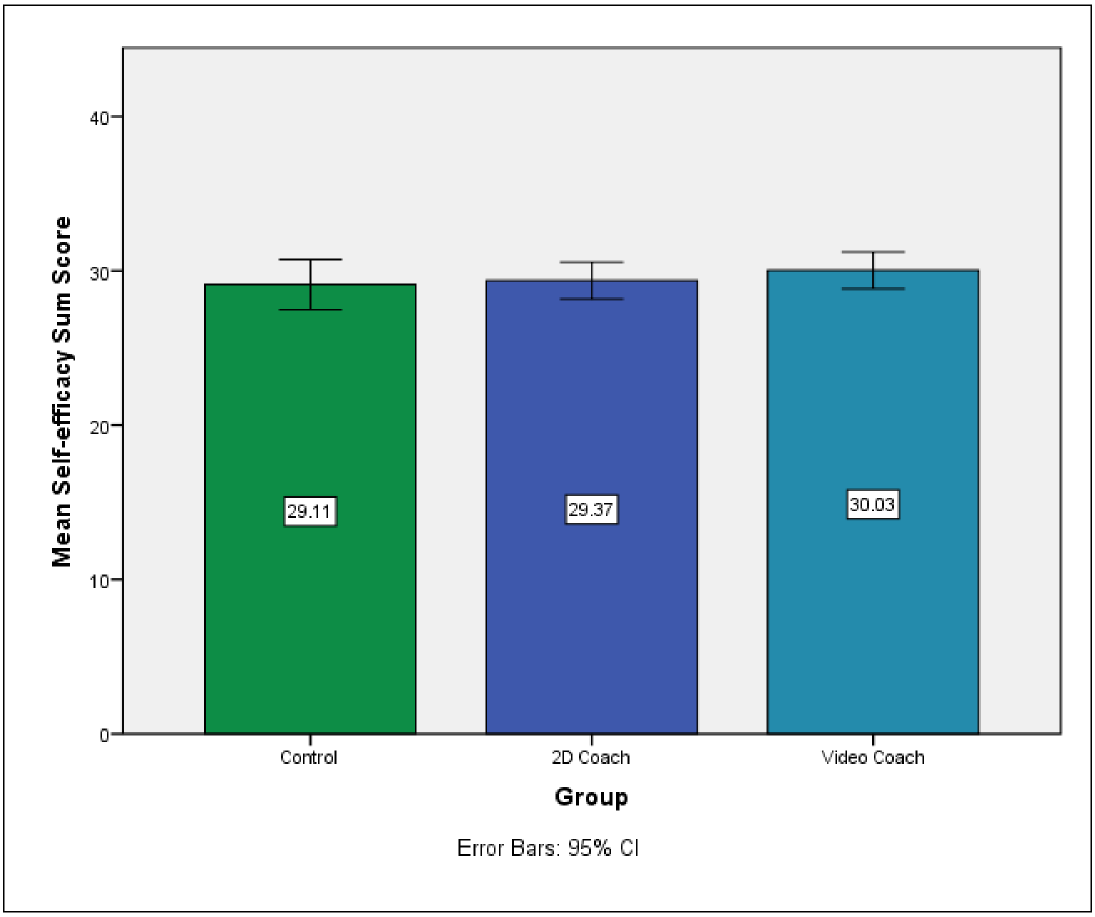


Figure 7.3. Self-efficacy sum score means for the three groups.

Qualitative 2D counsellor vs. video on screen evaluation study

Table 7.2 shows the generated list of categories and their subdivisions.

Hierarchy	Themes and sub-themes
1	**Connection/engagement with the robot**
1.1	Negative
1.2	Neutral
1.3	Positive
2	**Facilitation of planning/visualization**
2.1	Negative
2.2	Neutral
2.3	Positive
3	**Feelings/Importance of imagining goals**

3.1	Negative
3.2	Neutral
3.3	Positive
4	Influence of mental imagery on confidence/motivation/strategies for change
4.2	Neutral
4.3	Positive
4.4	Positive
5	**Impact of mental imagery on physical activity**
5.2	Negative
5.3	Neutral
5.4	Positive
6	**Recommendation/use of virtual coach in the future**
6.1	Negative
6.2	Neutral
6.3	Positive
7	**Overall evaluation**
7.1	Strengths of the intervention
7.2	Criticism/suggestions for improvement

Reliability test

The inter-rater reliabilities were calculated for two samples of units (PH3004 and YU2304) with the agreement rate being 85% and 95% respectively. The coding scheme was assumed reliable.

Participants' evaluation

Program evaluation

Participants from both conditions—2D coach and video coach on the computer screen—gave their feedback anonymously through the evaluative open questions. Participants from both conditions seemed to have an analogous experience with slight differences.

Connection/engagement with virtual coach

The responses for both delivery methods were similar in this item. The interaction with the 2D and video coach prompted words like 'surreal' or 'intriguing'. Other words were used in the evaluation of both 2D and video coach such as 'interesting', 'calming', and 'enjoyable'. Most of the participants found the counsellor engaging while some found her moderately or not very engaging. The tone of voice was often cited as calm and relaxing. Others criticised the counsellor as being monotone or patronising.

> *I personally found her very engaging, the tone of her voice was particularly calming and maternal. It nearly felt like I was interacting face to face with a live counsellor. (OR2001). 2D coach*

> *[It] was like quite like talking to a real person. (IO1602). Video coach*

> *It was quite captivating. (BI1996). 2D coach*

> *I felt that I was engaged 80% of the time, her voice was slightly monotone so I did lapse concentration occasionally. (TI2708). Video coach*

> *As she maintained regular eye-contact, smiled and used hand gestured, very connected. It almost seemed like a real person. (YI2310). 2D coach*

Fairly well connected, I think the more it is used the stronger the connection would get. (IA0102). Video coach

It was slightly surreal being spoken to by a hologram. (RR0610). 2D coach

I feel I connected to the virtual counsellor as much as I would if she was in person face to face. (II0502). Video coach

[I felt] not very engaged as it is simulated so there is no real contact. (BR0105). 2D coach

She was too programmed and with no personality making it impossible to feel connected. (RE0607). Video coach

Facilitation of mental imagery/visualization

The intervention was helpful in making the participants engage with the mental imagery exercises. Most participants commented on how the counselling session was productive in stimulating them to visualise their goals. Only a few found it difficult to visualise themselves or pointed that they could think about their goals without the imagery effect.

It was useful to imagine my goals so I then had a picture in my mind about what I wanted to aim for. (YU2304). 2D coach

I enjoyed being able to vividly imagine them as this made them seem more feasible to accomplish. (RE0607). Video coach

I couldn't put an image in my head. (GO1604). 2D coach

It was different to how I would usually go about it. I don't tend to picture things, just set it in stone that I want that particular thing done or I'd like to try to achieve it. I think the visual element was different and quite nice, though perhaps a little difficult to picture how others may react to you meeting your own goals. (BE3012). Video coach

Feelings/importance of imagining goals

The engagement with the mental imagery exercises unfolded a series of feelings related to the visualizations. The majority found it important to imagine their goals, making their objectives more clear. A few did not find important that they were able to visualize their goals.

Helped build an accurate picture I guess. I think it was quite important as it was the bit I did use at one point in the last 2 weeks to get me to exercise. (ML2910). 2D coach

I could imagine doing the exercise and realising that it wasn't as hard as I thought and that it felt better than I thought it would. (TH1407). Video coach

I think the counselling helped with increasing the desire and believing that I could achieve goals, as I visualized how I had achieved them previously. Imagining how good it would be and myself actually completing what I had planned made me more *committed to complete and stick to achieving goals by sticking to the plan. (IN2110). Video coach*

It helped me learn to build better pictures when imagining by imagining what success AND failure were like, and not just how it feels during the moment. (ML2910). 2D coach

Impact of mental imagery/strategies on motivation and exercise

The intervention had some impact on the participants motivation and in creating strategies to exercise more. The mental imagery exercises elicited further thoughts about how to apply the learned skill into their lives.

I could imagine doing the exercise and realising that it wasn't as hard as I thought and that it felt better than I thought it would. (TH1407). Video coach

From thinking about past times when I had achieved things, I could apply those thoughts to how I can achieve my current goal. (YU2304) 2D coach

It did help me visualize a time before Uni where I was much healthier and slimmer and so this motivated me to get back into routine. (YI2310). 2D coach

It helped me think that perhaps I could exercise more because I had learned a technique to make me feel more motivated, and because I could imagine how good I would feel and what all the steps I *needed to take were. This made me feel more confident, however I haven't really increased my exercise levels, so my confidence has gone down. (TH1407). Video coach*

I think the counselling helped with increasing the desire and believing that I could achieve goals, as I visualized how I had achieved them previously. Imagining how good it would be and myself actually completing what I had planned made me more committed to complete and stick to achieving goals by sticking to the plan. (IN3110). Video coach

The FIT session influenced many of the participants into taking action regarding their physical activity levels. The intervention seemed to have prompted many participants to exercise and others seemed to be instigated mentally but were not able to transform their thoughts and visualizations into actions.

Even though I didn't quite get into the routine I wanted, I've noticed that I've been more active in other ways like going on long walks where previously I would've been lazy, and always taking the stairs, so I've definitely improved even though I haven't yet reached my goal. (LA2003). 2D coach

Imagining myself actually doing the exercise and picturing how my body feels was very motivating and gave me the urge to work out. (TH1407). Video coach

That for a moment, it made me believe the "illusion" that my goal could have been easily reached. However, everyday life and actual routine say something different. (OR2001). 2D coach

It made me realize that a lot would be needed to achieve my goals, and when I actually did the exercise it didn't make me feel as good as I imagined the first few times which hindered my motivation. (IN3110). Video coach

I think it made me more motivated, I wanted to get fitter but I hadn't done much towards it for months, I've now actively looked into what fitness classes are offered and what the gym has on offer and plan to make use of it and see how it helps. (BE3012). Video coach

I booked onto more relevant classes at the gym which would help me reach my specific goal easily. (YU2304). 2D coach

Unfortunately I became ill for a week after the virtual counselling so was unable to improve physical activity then but I am now still feeling motivational to improve from the virtual counselling. (BM1208). 2D coach

Not particularly, I was busy with Uni. work so I couldn't really spent too much time. Also, the sport I spend most of my time doing is surfing and you need certain conditions and a lot of time to go surfing (last week, the surf was bad and I was busy). (OL0512). 2D coach

I motivated myself more to attend the gym and other physical activities which I previously avoided starting. (IN3110). Video coach

My physical activity did not improve after virtual counselling, but that was mainly because I was busy and didn't have the time. (PH3004). Video coach

Although it improved my motivation, I didn't spend enough time figuring how to do it in real life, so maybe sometime should be dedicated to figuring out when you're going to fit in the activities and writing that down. (LA2003). 2D coach

Recommendation/use of virtual coach in the future

Many participants were open to try the virtual coach again but suggested that it would be more productive if the encounter with the virtual coach would occur within a longer program or that it would complement a real counsellor. The majority would recommend a virtual counsellor to a friend but also advised that the friend should be prepared to fully focus on the mental imagery exercises, that it would be more effective to use alongside a real counsellor, or for an extended period for better results.

[I would recommend it] especially to someone who would maybe feel uncomfortable in the presence of a real counsellor. Perhaps knowing that it was a simulation which was delivering the same content would ease some anxiety which some people feel. (YA2310). 2D coach

If they were willing to accept that you have to engage fully in it and want to believe that it will help you. It requires you to immerse yourself into it. (YY0207). Video coach

Unlikely [that I would use a virtual counsellor again], but I may try and apply the skills in my own way to make it relevant to me. (ML2910). 2D coach

[I would use it again] not in a one off situation, maybe if it was used more regularly. (YE0712). Video coach

[I would recommend it] perhaps alongside a real life counsellor who you would be able to talk through your thoughts and feelings with and then use the virtual counsellor as an extra tool if it was needed, or after seeing an actual counsellor in real life. (YU2304). 2D coach

Overall evaluation

Strengths of the intervention

The best aspect of the virtual counselling reported seemed to be the lack of judgement. Many cited the fact that the virtual counsellor is less intimidating and easier to be around than a real counsellor. Another benefit pointed by participants was how the virtual counsellor facilitated focusing on their goals by creating mental imagery. By being less anxious by the presence of a non-human, they claimed to be more free to engage in the mental imagery exercises. Other positive appraisals revolved focusing on their goals and organizing mental strategies, short duration of the intervention, coach's soothing voice, and its calming effect.

> *Avoids any possible fear of judgement you may feel when carrying out those tasks with a person. (RN3006). 2D coach*

> *It's less intimidating because it's not a person who might judge you. (BI1996). 2D coach*

> *The virtual-style of it means I can forget surroundings judgements of others in the way I'm trying to improve. It becomes more about what I want from the session, and not about what is expected of me in the session. (ML2910). 2D coach*

> *It's not a real person so I was more honest in my answers. (EA1811). 2D coach*

> *Knowing it was a virtual counsellor as opposed to a real person (there's sometimes this feeling of pressure when it's a real person) and also tying my goals to my emotions as I feel this did motivate me. (Y12310). 2D coach*

> *It gives me time to think and imagine deeply, nobody is watching, the room is dark and I can behave as I want whether it means sticking finger into my mouth or simply just laying back and listening. (WA0802). 2D coach*

You could do it whenever you wanted and so if you were having a dip you could watch a video there and then without having to wait. (YY0207). Video coach

Imagining myself actually doing the exercise and picturing how my body feels was very motivating and gave me the urge to work out. (TH1407). Video coach

The best aspect of the virtual counselling was probably the focus on what my goals actually were. (PH3004). Video coach

Criticism/Suggestions for improvement

A variety of criticisms and suggestions were given by participants. Suggestions varied as using different categories with different sets of exercises for becoming more personal, shortening the session, having refresher or regular sessions, being given time to write down strategies, having a range of different counsellors to choose, having more interaction, among others.

Obviously there are limits to technology and this was only for a short study, but not being able to interact with the counsellor was the only limiting factor I can think of. (YI2310). 2D coach

Although you don't have the anxiety of speaking to a person, I would feel more committed if I had to report back to a person. (YN2411). Video coach

The worst aspect of virtual counselling was in spite of knowing my goals, I did not receive help on how to actually achieve them. (PH3004). Video coach

Maybe if there were different categories which the user could select depending on the kind of goals they wanted to achieve which would help it become a bit more personal. (YU2304). 2D coach

The counselling was excellent and gave me more motivation but it wasn't long term for me. (AL8919). 2D coach

Having different people for different clients, and taking individual differences into account. (LR2912). 2D coach

Virtual counselling could be improved by focusing more on how to achieve goals, rather than providing insight into what those goals are. (PH3004). Video coach

Discussion

This study tested the efficacy of a human video coach delivering a minimal FIT script containing mental imagery exercises only in two forms—2D and video screened—compared to a control group for physical activity motivation and engagement as well as their acceptability. Against our expectations, there was no significant difference in physical activity and self-efficacy, and goal motivation between intervention and control group. While there was no impact in terms of behaviour change, participants evaluated the program as helpful in learning mental imagery, claiming there was a brief boost in their motivation, and perceived both embodied and screened coach as non-judgemental.

A minimal FIT script without dialogue attempted to tackle the limits of the expectation of a personalised response by the coach. In face-to-face delivery, FIT has been shown to reduce snacking and weight compared to a control group (Andrade et al., 2016) and FIT has also led to more weight loss than MI in a randomised controlled trial (Solbrig et al., 2018). We predicted that not only added mental imagery could increase the effectiveness of MI, but focusing on engaging participants mentally only would have a greater potential for remote acceptability. This study did not show an advantage of automated FIT compared to a control group. The virtual delivery of exclusively mental imagery exercises might have impaired the potential of FIT. A comparison with the same methodology delivered face-to-face could elucidate whether there was an impairment of the minimal counselling technique or whether the remote delivery might have impacted negatively the potential of FIT.

We analysed Study 3 and 4 in parallel and they had analogous results. There was an initial motivational boost stated by many participants who claimed that this impetus wore off quickly. The lack of significant difference in behaviour change could be speculated as the short-lived motivational effect reported by participants. If goal motivation and physical would be measured one week and not two weeks after the intervention, the participants' motivational states could have been higher for both FIT conditions as they have reported in the written evaluation. Further research should test whether there was in fact a measurable motivational boost right after the intervention and the timeline of its decay.

There was no difference in self-efficacy between the groups, the same result as Study 3 even though several participants reported feeling more confident after the intervention in the qualitative evaluation. As stated in Study 3, the general self-efficacy scale might not have been optimal to grasp the confidence levels of participants in engaging with physical activity and a domain specific self-efficacy scale related to exercises could reveal more refined information in future related studies. Some participants of this current study as in Study 3 reported gaining more motivation but not actually transformed this power into action.

The IPAQ results showed that there was no effect of time or group, backing up how many participants described their difficulty in transforming motivation into behaviour. Misinterpretation of the questions led to an array of participants being excluded from IPAQ analysis. IPAQ has been shown to present problems of misinterpretations (e.g., Hallal et al., 2010). Direct measurement could be included in a further developments of this virtual intervention for a clearer assessment. There has been weak agreement with IPAQ compared with pedometer (Colpani et al., 2014) and with accelerometer (Tucker, Welk, & Beyler, 2011). Nevertheless, measuring physical activity through direct measures also has its deficiencies. A pedometer does not consider activities as swimming, for instance, and an accelerometer also has its limitations in capturing physical activity as not measuring upper body movement, for instance. Nevertheless, being aware of the amount physical activity taken might impact subsequent engagement with this behaviour (e.g., Weinstein et al., 1998; van Sluijs et al., 2007) and physical activity assessment might influence the control group as well.

Likewise Study 3, participants suggested that the encounters with the motivational coach should be more frequent. Studies with greater contact in website-delivered physical activity interventions have led to more positive outcomes (Vandelanotte et al., 2007). Further research would need to test whether our automated FIT would be more successful if not delivered as a single-shot intervention. Some participants suggested that the virtual coach should be used together with a real counsellor. Blended treatments aim at combining remote with face-to-face sessions in order to get the best of each modality for personalised treatment (Wentzel, van der Vaart, Bohlmeijer, & van Gemert-Pijnen, 2016). It might be the case that this minimal FIT intervention would have a better outcome if it would complement a face-to-face contact with a health professional as it would feel more personalised.

Even with no verbal interaction from participants, which had been reported beneficial in Study 1, 2, and 3, engaging silently with mental imagery exercises was positively appraised. The majority of participants reported that the visualization techniques were helpful in visualizing and setting goals and claimed it was important for them to learn this skill. Participants of a focus group trying to lose weight felt a FIT app would be helpful in helping them sustain motivation (Solbrig et al., 2017). This was an attempt to deliver FIT remotely with positive reported aspects even though it did not lead to behaviour change compared to a control group. The set-up and coach's voice was often referred as calming which contrasted with problems some participants had in understanding the robot in previous studies or even founding the mechanical voice quirky.

Several participants perceived the virtual coach as non-judgmental. This is a repeated effect from Study 2 and 3 but now with a 2D and video human coach and not a robot or video robot. The non-judgemental perception freed participants from the anxiety of interacting with a real person. Participants reported that they were able to be more relaxed and with no apprehension regarding the face-to-face effect of a counselling session. Computer-mediated communication has been shown to incite more self-disclosure than face-to-face (Joinson, 2001). The lack of perceived judgement then could be assumed that originates not from the interaction with a non-human technology as in Study 2 and 3—inherently free of judgement because of being a machine—but from the virtual delivery versus a direct human interaction. This remote form of delivery might be useful in the future not only for behaviour change, but for other aims such as to gather sensitive information that would not be released to a human being. Patients hide information from their clinicians for not wanting to be judged (Levy et al., 2018) and this type of virtual coaching might have a place in healthcare by inciting openness.

This study showed how a face-to-face counselling technique as FIT could be translated into a virtual delivery. The focus on visualization exercises makes FIT an applicable intervention through technology as it does not lose its essential characteristics as the difficulties in automating MI. The 2D and screened projection showed similar reported outcomes and the more presential technology did not show benefits compared to a traditional screened delivery regarding the evaluation of the intervention itself. Participants though used stronger words evaluating the hologram-like version. Further studies should test whether this 2D coach could be more efficient in other domains as its possible impact in memory or attention to understand how it could be helpful in healthcare. While our automated FIT did not show any impact on behaviour compared to a control group, participants evaluated it as a helpful tool to learn, which increased their motivation with the virtual coaches being perceived as non-judgemental and comments about the 2D showing it was more salient than its screened version. Future research still needs to test repeated sessions with 2D coaches, with sensitive measure of physical activity, and with a tailored design based on a branching script.

Chapter 8: Methodological Study Design Limitations

Overview of study designs

The aim of this PhD project was to create new technologies for behaviour change. The first step was to focus on the development of virtual coaches that would be, firstly, acceptable, and secondly, effective in changing behaviour. The opportunities for developing technologies, testing its technological and counselling technique acceptability as well as the effectiveness in change behaviour turned this project into an ambitious endeavour. The four empirical studies reported in this thesis provide a spark for further investigation in the mesh of psychology with technology. This chapter explores the rationale behind the study designs as well as weaknesses in their methodologies.

Below is a table (8.1) with the design of the four studies in order to provide an overview of how the empirical work has developed. The table depicts the technology employed (delivery modes), presence of technology (embodied or screened), form of engagement (either a dialogue or monologue), type of counselling technique employed (either MI or FIT), dependent variables (assessment tools), and MI change talk analysis (present or absent). In the next subsections, the main items will be broken down for an observation of separate components of the study designs.

Table 8.1: Overview of the four empirical studies.

Study	Technology	Presence	Engagement	Counselling technique	Dependent Variables	MI change talk analysis
1	Human on video	Computer screen	dialogue	MI	Qualitative (Open-ended evaluation)	Yes
2	Robot F2F	Embodied (F2F)	dialogue	MI	Qualitative (Open-ended evaluation)	No
3	Robot on video	Computer screen	dialogue	MI & FIT	Qualitative (Open-ended evaluation) & Quantitative *IPAQ – physical activity *GMS-PA – motivation for physical activity *General self-efficacy questionnaire	No
4	Human on 2D Hologram & video	Embodied (Silhouette projection) & Computer screen	monologue	FIT	Qualitative (Open-ended evaluation) & Quantitative *IPAQ – physical activity *GMS-PA – motivation for physical activity *General self-efficacy questionnaire	No

Technology development and acceptability

We aimed to develop new technologies by trying to find a balance between acceptability and potential for being fully automated. The core of this PhD project was the creation of such technologies. A large part of the research time was devoted to conceptualizing and developing the technologies themselves as detailed in Chapter 2. The empirical studies qualitatively tested whether they were acceptable. As previous remote deliveries, based on MI, used text responses (Shingleton & Palfai, 2016), which deviated from traditional interaction, our main endeavour was to mimic face-to-face dynamic as much as possible. The main goal was to create technologies that would be analogous to a presential counselling session with a live counsellor and clients answering out loud. We specifically wanted to emulate a face-to-face session in the sense of eliciting similar client behaviour. The focus was on using technology to produce the psychological benefits for participants of speaking aloud about goals and plans (studies 1-3) and imagining future successes and pathways towards them (studies 3 and 4), rather than on mimicking human counsellor behaviours.

The project started with a human coach screened on a computer (Study 1) as the construction would be easily embedded into websites and apps for wide dissemination. With inspiration in the positive results in videoconferencing (Backhaus et al., 2012) and popularity of video chat tools, our approach attempted to establish an automated delivery similar to live interaction through video. We tested the automated video dialogue in the form of a simulated Skype conversation. Participants found the technology easy to use and talked to it about their plans for change. However, many felt self-conscious about using the webcam and found the lack individually tailored feedback rather impersonal.

Based on these negative aspects of participants' experiences, we decided to approach the automated counselling through a non-human interaction. We expected that a face-to-face interaction with a robot (Study 2) would gain through its embodiment, and reduce perceptions of impersonality as participants hold lower expectations about robots (Slater & Steed, 2002). The same MI script used in Study 1 could be delivered by the robot to evaluate how people would interact with this non-human technology as opposed to the video counsellor. One of the supervisors of the project is a social roboticist, which facilitated the process of selecting a robot that could be used as a counsellor. Through qualitative studies (1 and 2) we could gather more information about the perception of each type of technology employed (human and screened versus robotic and embodied).

Participants did enjoy their interaction with the robot (Study 2), but still mentioned that it felt impersonal. They appreciated advantages of the robot being non-judgemental and novel. We wanted to retain these advantages but faced the dilemma that a researcher had to monitor the robot, to prevent damage or inappropriate use, which made it not completely feasible for broader dissemination. For this reason, we opted to retain the advantages of the robot, but in a way that it could be fully automated so it could be more easily disseminated. A video robot (Study 3) would be able to deliver an automated counselling session that could be played from multiple computers at the same time. Because of the negative feedback related to the webcam in Study 1, we took off this component for a potential greater acceptability. We introduced FIT as an alternative counselling technique because it has a lower focus on dialogue as a key psychological component is eliciting participants' mental imagery. We hoped this would counteract the sense of impersonality (studies 3 and 4).

We also saw in FIT a chance to test a different type of technology—a 2D hologram—and approach the problem from a different perspective (Study 4). No other team of researchers in healthcare had used this video embodied technique before, as far as we are aware, and this was an opportunity to compare directly this set-up against a screened version. With the positive appraisals in the interaction with the embodied robot, we aimed at testing whether there would be any advantage of a life-size projection over a computer screen presentation.

Compared with a robot, a human would be able to give more nuances in their voice when delivering the mental imagery exercises, and for this counselling technique, could offer advantages over a machine, for example by speaking softly during the imagery exercises. A challenge with using a 2D projection for delivering psychological interventions is that the human actor needs to be filmed in one take and with minimal head movements or gestures because the illusion of speaking to an embodied human is lost if the video projection exceeds the boundaries of the acrylic screen which is cut to the exact size and shape of the projected image. Inserting 'listening' segments with variable durations, under the participant's control, would be technically difficult and risk breaking the illusion of human interaction. We anticipated that the imagery exercises in FIT would be psychologically effective even without dialogue about the participant's problem. To test if the embodied 2D coach was acceptable and effective, Study 4 compared it with the same video presented via computer screen. With our set of studies, we were able to analyse the acceptability of embodied robot (Study 2) and human (Study 4) as well as their screened versions (Study 1, 3 and 4) and the pros and cons of each mode of delivery.

We developed a range of techniques that can be used to explore psychological interventions delivered by technology without pushing artificial intelligence, like voice and emotion recognition, to its limit. Firstly, studies 1, 2, and 3, introduced a dynamic spoken counselling interaction. The format of delivery supported research that found embodied versions—physically present robots—are more fun and prompt higher empathetic responses, but that screened versions provide similar effectiveness (Fasola & Mataric, 2013; Li, 2015;

Paiva et al., 2017). Our results suggest that embodied versions might be slightly more remarkable, but screened versions were also perceived as effective besides being easily disseminated and able to reach a greater number of people. There were multiple comments about the non-judgmental nature of our virtual coaches, both embodied and screened, both robots and humans. People tend to disclose more negative information (Joinson, 2001) or risky behaviour (Gerbert et al., 1999) online than in person and our studies showed that the participants did mention feeling freer to be more honest with the virtual coaches. The only study in which this non-critical effect did not emerge was the first one in which participants felt self-critical about seeing their image on the webcam. Previous research has shown that people with anxiety have less eye contact with a webcam and it can lead to negative self-evaluations (Howell, Zibulsky, Srivastav, & Weeks, 2016). Study 1 showed that the use of webcam with virtual coaches can be challenging even with an unselected sample. These findings can serve as a basis for future virtual coaching development, building on the positives of a non-judgemental, spoken interaction with technology while improving the responsiveness of the technology to participants' specific answers and avoiding use of a webcam.

MI versus FIT

We began with MI because it has been an effective brief behaviour change counselling technique in face-to-face delivery (Burke et. al, 2003) and had already had some previous adaptation to technologies (Shingleton & Palfai, 2016). We saw an opportunity to develop a dynamic remote delivery that had not been attempted before. Our proposal was to focus on two main components of MI that were not much explored in previous TAMIs, open questions and the space for the client to speak up. Participants did value the most the space given for them to speak about their goals and motivations (Study 1, 2 and 3), and produced considerably more change talk than sustain talk (Study 1).

We predicted that FIT would reduce participants' perception of the interaction as impersonal. In face-to-face delivery, FIT counsellors use active listening skills such as reflection to elicit emotional depth, as do MI practitioners, and to help participants refine their imagery. Although the technology we used could not employ this skill, we anticipated that its absence would be less obvious because participants would be focusing on the guided imagery element. Study 3 was an opportunity to directly compare these two counselling techniques. Because of time management issues, we planned studies 3 and 4 to run simultaneously. Study 4 applied a minimal FIT, in an attempt to reduce further the impersonality with all the work being through mental imagery exercises in a monologue format, which also fitted the 2D hologram projection. As an intervention of only one encounter, our TAMIs and TAFITs were able to provide space for the participants to talk out loud or engage mentally, which was one the main strength that participants reported. Contrary to our prediction, FIT did not do better than MI, and neither technique presented an advantage compared with a control group in terms of changing behaviour. The design of these studies (3 and 4) might not have been ideal to capture change, which will be discussed in detail in the section 'Reasons for choosing each study design.'

Nevertheless, our results inform future developments of TAMIs and TAFITs. Open questions are part of MI-consistent behaviours that lead to increased change talk (Pace et al., 2017) and change talk is one of the main ingredients of MI (Apodaca & Longabaugh, 2009). This thesis represents the first demonstration that humans will talk to technology about their behaviour change goals in a way known to be psychologically effective. Even recent studies that focus on 'change talk' in TAMIs have constrained participants' responses by having them select 'change' or 'sustain' text options rather than speak freely (Olafsson, O'Leary, & Bickmore, 2019). We have also shown that most of our virtual coaches were perceived as non-judgemental, showing that participants bring to the counselling session their own anxieties that can be counteracted with a non-critical environment. People withhold information from their clinicians if they are afraid of being judged (Levy et al., 2018) and our results showed that participants reported being able to be more honest in these virtual counselling interactions than they would be with a human. We shall return to this issue in Chapter 9.

Behaviour Change

Improvements in physical activity prevent a series of health conditions (Sundberg, 2016). We chose physical activity as the target behaviour because recruitment of participants would be relatively easy. Given the broader impact in wellbeing and the accessibility to physical activities, college students would be highly available to test these technological interventions. However, the plan was to develop virtual counselling technology that would be useful for different types of behaviour change. The goal was not to create an automated delivery specialized for physical activity engagement, but that this target behaviour would be used to test the application of our remote interventions.

In Study 1, we produced a generic script and informed the participants prior the experiment that they should reply to the questions regarding physical activity. The reason for this generic approach was that the intervention could be applied to different behaviours in the future. For instance, participants could be informed before that they should reply to the questions regarding smoking reduction or weight management, for instance, and the automated counselling session would still work. Informing the topic just once before the interview had the problem of producing misunderstanding in how the questions should be answered. All the participants in Study 1 did reply to the questions in terms of physical activity, but one. A distracted participant engaged with the interview with the goal of quitting smoking, which was a mistake for this study's purpose, but showed how the intervention could be applied to different behaviours.

To avoid having participants replying about another behaviour that was not requested, Study 2's script was adapted to concretely state that the behaviour change was physical activity engagement in every question. Studies 3 and 4 followed the same pattern with scripts that were not specialized for physical activity. Our vision to the future, trying to develop a technology that would be useful to different types of behaviour was bold, but in practical terms, the generic script can lose its power to influence a more specific type of behaviour.

Having established that the virtual coaches (studies 1 and 2) were well accepted, studies 3 and 4 aimed at measuring goal motivation, self-efficacy, and physical activity in randomised controlled trials to test if they engendered differences in motivation and behaviour. We found no difference between interventions and control groups. The next section will question whether the study designs were problematic for testing our technological interventions and whether it was premature to test efficacy instead of working with potential users to develop the interventions further.

Reasons for choosing each study design

Study 1

A human virtual coach engaged participants in a MI where participants spoke aloud to a pre-recorded interviewer. We used a qualitative approach to explore the acceptability of our developed TAMI one week after the intervention. The qualitative approach aimed at extracting information in a range of topics, from how participants engaged to technology to how they got motivated to change their physical activity levels. The strength of this methodology was to gather a broad range of information that would emerge from participants and not to constrain the research questions in quantitative questionnaires. We tried to gather knowledge about different topics: technological interaction and acceptance, engagement with the counselling technique, influence in motivation and behaviour change. And we used a thematic analysis to identify the patterns in the participants' responses. The limitation of this strategy was to not have a precise line of investigation.

Study 1 became a paper entitled "Say it aloud: Acceptability of a spoken motivational interview delivered by video counsellor," submitted to the Internet Interventions journal. Even though the manuscript received compliments regarding its innovative approach, being the first time the reviewer had encountered a TAMI that encouraged participants to answer a video counsellor out loud, he/she pointed out that the aim of the study was not clear. The reviewer identified as the main flaw of the study trying to test the acceptability of the intervention while also claiming that the video counsellor could help enhance the discrepancy and elicit change talk as well as encourage participants to set and articulate subgoals, consider obstacles and plan actions. The reviewer also pointed out that adding questions about motivation to change and engagement in physical activity after the intervention in the evaluation questionnaire obscured the goal of the study. Other suggestions were to include: how long a session lasted, how long the participants responded out loud, more information about the development of the MI script, and increased description of the evaluated questionnaire. Due to the cited reasons, the reviewer advised against publication.

Taking into consideration the feedback from the Internet Interventions reviewer, we realized that we could analyse change/sustain talk in participants' interactions with the videocounsellor to give more substance to our claims regarding the benefits of the MI interaction. We had video recorded the sessions to make sure that the interviews ran as planned, that the participants actually spoke out loud to the interviewer, and that there were no technical problems during the delivery of our TAMI. With the feedback from the Internet Interventions reviewer though, we realized that, as we had these recordings, we could use them for further analysis, to add weight to the claimed contribution of our TAMI.

Analysis showed greater change talk compared to sustain talk for each of the participants as well as across the group, attaining one of the goals of MI. This change/sustain talk analysis was an addition to the paper, supporting claims that this TAMI's design with open questions did lead to change talk. The change talk analysis, though unplanned, gave us confidence that 'dialogue' with technology encouraged the sort of talk that is considered psychologically effective in face-to-face counselling. Thus, the basic and novel approach of getting people to talk to technology had potential to strengthen their motivation.

The paper had not only a qualitative approach to the acceptability of the technology and video MI but included, at this point, a quantitative analysis of one of the main ingredients of MI, change talk. We were not able to resubmit to Internet Interventions once the change talk analysis was done as the CogNovo project had just ended and there was no funding left for article processing charges. Funding has now been found and the paper is resubmitted to Internet Interventions.

Study 2

We used a NAO robot to deliver a face-to-face MI as an alternative to a human coach to explore the acceptability of this type of technology in encouraging physical activity in another qualitative analysis. This second exploratory study aimed at investigating the acceptability of a live robot, the MI engagement, and influence of our TAMI in motivation and behaviour. Study 2 concentrated on the benefits that participants reported in Study 1 in speaking aloud about their goals and motivations, but in a face-to-face contact with a robot, which could lead to fewer expectations about a personalised feedback due to its non-human nature (Slater & Steed, 2002).

There was no webcam as it was a live robot. The robot's eyes do have a camera, which monitored what was happening in the room with the participant; however, there was only visual and no audio feedback, therefore, no further analysis of change talk was executed retrospectively. Even though Study 1 was not published, Study 2, with the same study design was accepted in the Journal of Medical Internet Research. The reviewers found the use of a robot to deliver MI novel and considered the importance of participants' hearing themselves interesting as well as the fun and non-judgemental nature of the interaction. In comparison to Study 1's paper, the robot seemed to have called more attention because of its novelty as opposed to a video counsellor. The result regarding the non-judgemental aspect of this TAMI was also mentioned and seems to have contributed to the positive evaluation of the paper for publication.

Only one other group of researchers, (Kanaoka & Mutlu, 2015), used a NAO robot to deliver MI, and their results were not published in a journal but were available from the Proceedings of the 33rd Annual ACM Conference Extended Abstracts on Human Factors in Computing Systems. Our paper seems to have been the first publication in a journal of a NAO robotic TAMI. Previous TAMIs had used video counsellors before but their dynamic did not offer participants to speak out loud, which was the novel aspect of Study 1. We could suggest that the innovation in using a robot (Study 2) was fundamental for its publication.

Study 3

In Study 3, we decided to run a randomised control trial to test whether these virtual coaches would be effective in changing behaviour. We employed the use of a screened robot to develop a technology that could be fully automated and reach a greater number of people as opposed to an embodied robot that requires a researcher to monitor it. Because of the comments participants expressed about feeling frustrated about the lack of verbal response from the virtual coach, we expected FIT to be more effective than MI. But as we had not tested the efficacy of our TAMIs before, we needed to test both in comparison to a control group. After two exploratory studies (1 and 2) focusing on a qualitative approach, we wanted to use quantitative methods to test its impact in changing behaviour. Study 3 and 4's designs were analogous, testing different components of the health intervention in RCTs. Study 3 investigated whether there would be a difference between a technologically delivered MI versus FIT against a control group.

Our study design focused on one-shot interventions that we expected to have an impact in increasing physical activity levels. MI is a counselling technique that has been effective in face to face in a brief format (Burke et al., 2003). With the two-week interval to measure behaviour we intended to capture a more consistent change instead of a boost right after the intervention. We aimed at measuring the impact of our TAMI and TAFIT in terms of changing goal motivation, self-efficacy, and physical activity levels. We measured motivation and self-efficacy as there should have been increased by an effective intervention even if this increase did not translate into actual behaviour change.

To gather more information regarding the interaction with these virtual coaches, we also decided to apply a qualitative questionnaire to keep thematically analysing the feedback from participants and be able to compare with the perception of the previous virtual coaches (Study 1 and 2). The design of the RCT might not have been ideal to detect change and the qualitative questionnaire provided some of the answers. The weaknesses of the study design will be discussed in the section "Problems encountered when applying these designs and lessons learned."

Study 4

We tackled the lack of reflection and personalised interaction from the exploratory studies by developing a FIT only intervention, with a minimal script, giving space for participants to engage exclusively mentally to the virtual coach in order to avoid the high expectations of a verbal response observed in the previous studies. In our second RCT, instead of testing the difference between counselling techniques delivered remotely (Study 3), we aimed at comparing delivery modes (embodied versus screened) with FIT as a monologue. We expected that the embodied version would show an advantage over a screened virtual coach, in terms of participants' experience and behaviour change. We used the same design as for study 3.

The study designs of the last two studies tried to answer a large number of questions, which might have been not optimal as an overall development for the PhD project.

Problems encountered when applying these designs and lessons learned

Although the main focus of the PhD project was to develop the technologies themselves, the empirical studies tried to cover a broad number of areas, which might not have been the ideal choices. There was a diverse range of potential investigations. We used different types of technologies (embodied and screened; human and robot), two counselling techniques (MI and FIT), as well as measuring the impact in terms of motivation, self-efficacy and physical activity engagement. Trying to explore all these aspects, bringing psychology, social robotics, and technology in one project was challenging regarding the study designs.

From the pilot studies of our TAMIs, we jumped to RCTs to test the impact of the interventions in changing behaviour (Study 3 and 4) as well as maintaining the qualitative approach to gather further information. While in Study 3, we compared MI against FIT; in Study 4, we tested embodied versus screened delivery. With a different set of research questions, the focus dissipated. In retrospect, it would have been useful to first explore the technological deliveries with more rigorous tests of their acceptability in order to move from prototypes to a more refined virtual coach with less rush to test the effectiveness of our tools.

In a systematic review of guidance on how to proceed with full-scale evaluations of public health interventions, Hallingberg et al. (2018) argue that the pre-requisite activities for conducting exploratory studies are: determining the evidence base, establishing the theoretical basis for the intervention, and identifying the intervention components and how they interact and impact the final outcome. Exploratory studies should help refine the intervention and address uncertainties. They encourage qualitative research and recommend that researchers explore uncertainties about the intervention implementation (acceptability, feasibility, or practicality) before testing for effectiveness. Pilot studies are used to test feasibility in preparation for a major study as well as a pre-testing a research instrument (van Teijlingen & Hundley, 2002). This team of researchers propose that one of the pros of pilot studies is the chance to check where the project could fail. The four empirical studies developed in this PhD thesis could potentially guide the design better studies to investigate the TAMIs and TAFITs.

A range of pilot studies with different study designs have also been conducted on TAMIs. Some of these studies have informed the development of our own studies as the use and conceptual development of video coaches in TAMIs, for instance. Gerbert et al. (2003) ran a preliminary study to find out which video counsellor participants would pick. We ran a similar study when preparing study 1. Next, in a pilot study, they tested the feasibility and acceptability of the video doctor computer program to deliver a brief MI-based intervention for smoke and alcohol reduction. The researchers assessed the perceptions of the participants in a structured interview as well as with multiple-choice questions. Other researchers have also investigated the overall perception about the interventions. Walters et al. (2014) conducted a pilot study (n=21) to access a web-based intervention based on MI targeting substance abuse in the criminal justice system. Participants completed a Likert-scale response form and answered to written open questions about the program. Osilla, D'Amico, Díaz-Fuentes, Lara, & Watkins (2012) ran a pilot study to access a multicultural web-based MI for clients with a first-time driving under the influence (DUI) offence. They employed an iterative formative assessment using focus groups with staff (n=8) and clients (n=27) as well as usability interviews with clients (n=21) with open questions. We followed these researchers' approach of collecting qualitative data but used a computerised questionnaire with open-ended questions rather than a face-to-face interview. We did not use multiple choice or Likert scale questions because we did not want to influence or constrain participants' responses. With hindsight, the iterative approached used by Osilla et al. would have helped us refine the intervention—for example by indicating whether participants would welcome multiple intervention sessions—before attempting an RCT.

Different methodologies have been used to gather information about users' satisfaction with TAMIs or usability of the intervention. Ahmedani and colleagues (2015) ran a pilot study (n=130) to test the feasibility of a brief mobile health intervention for depression among patients with chronic pain with elements of MI. Participants were asked a series of satisfaction questions to evaluate the intervention as well as they measured depression levels before and after. Markham et. al (2009) executed a pilot study (n=32) to test a web-based sexual risk reduction intervention for HIV-positive youth based on MI. They accessed the usability (ease of use, credibility, understandability, acceptability, motivation) using Likert scale ratings adapted from pre-existing usability assessment instruments and pre- and post-ratings on psychosocial outcomes.

The above studies used qualitative interviews, multiple-choice questionnaires as well as focus groups in their study designs for their pilot studies in order to understand the response to their TAMIs. Some also measured behaviour before and after for a prediction of the impact of their tools. There is not a standardised form of designing pilot studies for testing virtual coaching, but a mix of methods brings information from different angles about a new intervention. Each methodology presents pros and cons. For instance, focus groups as used by Osilla et al. (2012) counts on the diversity of the interviewees but misinterpretations or personal bias—as one participant's opinion driving the group—can lead to questionable results. Quantitative questionnaires as employed in Markham et al. (2009) can be more objectively compared to other results but lack the depth of information of a structured interview executed by Gerbert et al. (2003). What we did in our studies was to develop different technologies and collected qualitative data on how users found them, using the same methods each time so we could compare across the technologies, trying to find a balance between acceptability to the user and potential for automatisation. In terms of qualitative data, our research provides a starting point for other possible approaches. Questionnaires about the functionality, usability and user experience though could be used in addition to our qualitative approach in these exploratory studies in order to investigate quantitatively the acceptability of our virtual coaches. Although clearer objectives would have given more information about acceptability of the technological encounter, the open-ended questions that we used led to broader data without imposing preconceptions on participants.

McNamara & Kirakowski (2006) consider three primary elements when evaluating technology: the product itself, the interaction between user and the product, and the experience of using the product, making a distinction between functionality, experience, and usability. The technology acceptance model is related to the perceived usefulness and perceived ease of use of a product and has a hedonic aspect to it while the user experience (UX) models look at the experience and consequences of those experiences and its connectedness (Hornbæk & Hertzum, 2017). In our exploratory studies, we could have investigated the human-technology interaction aspects of our prototypes beyond the qualitative questionnaire employed. For instance, the USE Questionnaire: Usefulness, Satisfaction, and Ease of use (Lund, 2001) could have been helpful in order to acquire quantified data about the participants' experience interacting with our created tools, applying the technology acceptance model. A quantitative approach in how the users would evaluate the intervention could add in terms of comparability of the virtual coaches within this PhD project as well as virtual coaches developed by other researchers. Once having used the technology acceptance model to establish whether our tools would be useful and perceived ease of use, in a second level we could have investigated our tools with the user experience model with a focus on the participants' experience and consequences of their interaction with our virtual coaches.

There are different ways in which this PhD research could have taken, approaching the problem from difference perspectives. One option would be to develop one novel technology, analyse what users thought of it, and then worked with them to improve it. Another alternative would be to develop several technologies, as we have done, and work with users to discover which they would prefer, by exposing them to all the technologies. The next step would be to run some pilot studies to test how it would work when they are left to use it without experimenter interference, and finally, run an RCT that tests the best possible version. Further pilot testing would have told us whether to design the virtual delivery of our TAMIs and TAFITs in a format analogous to Solbrig et al.'s (2018) study in which face-to-face FIT outdid MI for weight management, with both interventions including booster sessions, or whether the format needed changing to optimise virtual delivery.

Rather than develop multiple technologies, we could have developed one technology and used it in different ways, for example, to deliver a one-off session or repeated sessions and test whether it would work for both. Some questions to investigate would be whether the novelty wears off or the person develops a ‘relationship’ with repeated interaction. As FIT is a novel counselling technique that has not yet been tested that much empirically, we could also just focus on TAMIs and advance further the knowledge that had been established in the automation of MI. The change talk analysis showed that our open questions did lead to this important MI ingredient. If the focus would be to advance the knowledge of TAMIs, we could have investigated further other MI ingredients and how we were able to prompt them or how each of the elements contributed to the perception of our tools.

The Medical Research council’s evaluation framework characterises the development and evaluation process of an intervention in four levels: development, feasibility and piloting, evaluation, and implementation (Craig et al., 2008). They suggest researching existing theory and evidence as a basis followed by initial testing with a series of pilot studies for exploratory evaluation. In order to access the effectiveness of an intervention, randomisation should be considered since it is the most robust method of preventing selection bias. An adjunt to conventional RCTs is to evaluate the processes that determine how an intervention is best implemented and received (Oakley, Strange, Bonell, Allen, & Stephenson, 2006). By processes, this group of researchers mean ways to examine the view of participants about the intervention, studies of how to implement the intervention, distinguishing components or contextual factors that affect an intervention, and access the reach of the intervention. We could have analysed processes that would be important for embedding our technology in healthcare, or analysed the mechanisms that underpinned any beneficial effect, for instance whether perceiving a positive alliance with the technology is important.

Previous RCTs of TAMIs have tended to focus on assumed precursors of behaviour change rather than directly measuring behaviour change. For example, Multiple forms of designing RTCs have been developed for testing TAMIs. Some examples follow. Alemagno and colleagues (2009) ran a RCT to test a brief motivational intervention based on MI to reduce HIV risk and increase HIV testing among offenders. They tested 212 participants divided into experimental (computerized-self-directed interview including videos) and control (written educational material) groups. Both baseline and follow-up interview questions focused on drug and sexual behaviour associated with HIV risk. Results showed a significantly higher rate of HIV testing for the intervention group and also they were more prone to consider behaviour changes. Blanson Henkemans et al. (2009) conducted a RCT on a persuasive computer assistant based on MI with 118 overweight people. They measured the difference between a lifestyle diary use with and without computer assistant feedback. Results showed that the assistant did contribute to filling the diary more frequently. In a RCT targeting tobacco addiction (n=97), Breland et al. (2014) tested a TAMI against a control group receiving resource information. Participants returned four and six weeks after the intervention. Quit rates were not significant, but participants in the intervention group reported a greater interest in quitting smoking. Alemagno et al. (2009) reported the readiness to change of the participants, Blanson Henkemans et al. (2009) focused on diary entries while Breland et al. (2014) report a greater interest in the participants in quitting smoking as opposed to testing the efficacy of their tools in actually changing behaviour. Studies 3 and 4 in this PhD likewise measured precursors of behaviour change, specially motivation and self-efficacy, as well the target behaviour. Unfortunately there was no observable impact of the intervention on those measures.

The overall aim of the PhD project took different roads, trying to answers questions in a range of directions: the acceptability of different forms of technologies (human versus robots; embodied versus screened), the difference between two counselling techniques (MI versus FIT), as well as the impact of our tools on behaviour. Our RCTs were, somewhat, premature, trying to work on too many aspects of the intervention, testing the effectiveness of different counselling techniques (MI versus FIT) in Study 3 and technological deliveries (embodied versus screened human coach) in Study 4 in changing behaviour.

Instead of designing two RCTs testing effectiveness, we could have developed more pilot studies and one larger RCT, in which we could still focus on the relationship between human and machine, the mechanisms of the counselling technique employed, or an analogous design to Solbrig et al.'s (2018) study as mentioned before.

Our study designs developed as the research unfolded in many directions. In retrospect, trying to achieve results in different areas might have hurt the potential of a better defined focus. Nevertheless, this PhD showed that psychological interventions can be adapted to embodied and screened technologies while retaining the key component that participants engage in dialogue where they hear themselves speaking aloud about change without feeling judged.

9: General Discussion

Overview of findings

This PhD project explored the development and assessment of embodied and screened virtual coaches for behaviour change, aiming at encouraging physical activity. The first empirical study consisted of a human coach delivering MI in a dynamically simulated video chat. This intervention focused on open questions, one of the main MI assets, giving space to participants to interact verbally. Focusing on verbal dialogue makes this TAMI different from previously conceived TAMIs with video coaches, which prompted text-based replies (e.g., Gerbert et al., 2003). The space for participants to voice goals and motivation led to high instances of change talk. However, participants felt self-conscious about the webcam projecting their live image on the screen. Participants also missed the personalised interaction and reflection that a human coach would have provided. Nevertheless, even with a general rather than a personalised approach, participants valued voicing their goals aloud and listening to themselves, being consistent with self-perception theory (Bem, 1972).

The second study tested a more radical alternative to human counsellors. People hold higher expectations when interacting with a human-like representation than with less realistic ones (Slater & Steed, 2002); therefore, a robot could reduce the expectation of a personalised response, offering advantages in comparison to a human coach. We used a NAO robot for a face-to-face MI session. Most participants found the interaction with the humanoid robot fun, novel, and engaging. Kanaoka & Mutlu (2015) used a NAO robot in a similar design but their participants were frustrated by lack of fluency in the dialogue due to its limited speech recognition system. Our simple push-and-advance methodology focused not on trying to interpret what participants expressed, but on giving space for them to talk out loud freely without being interrupted. This approach aligned with MI principles, and, as Study 1 showed, evoked change talk. One of the key findings of Study 2 was that participants welcomed the non-judgmental aspect of the delivery by a robot, something which did not feature in the responses to the video counsellor. The robotic MI also presented shortcomings. As in the first study, participants still negatively evaluated the lack of personalisation.

It is a challenge to translate MI to any type of technology because of its reliance on verbal dialogue and the current limitations of artificial intelligence for understanding and responding to free human speech. In the third study, we introduced FIT as an alternative counselling technique. FIT is based on MI but uses mental imagery exercises throughout the interview. The lower reliance on verbal exchange might reduce participants' expectations for a personalised response while the imagery exercises increase the effectiveness by amplifying emotions (Solbrig et al., 2018). We used a screened robot to develop an interaction that could be fully automated and reach a greater number of people than could an embodied robot that requires a researcher to monitor it. Study 3 measured physical activity through self-report on the IPAQ. Against our predictions, neither MI nor FIT produced differences in behaviour change compared to a control group. Qualitative responses showed that participants praised the space to talk out loud in MI or also mentally engage in FIT with the screened robotic coach, but still missed a personalised response. The video robotic intervention produced the same non-judgemental impression as the physical robot from Study 2, suggesting that this might be a general feature of conversations with a robot.

The dialogue still presented a barrier in Study 3 for a fluent interaction which led us to invest on another approach in the fourth study: a minimal FIT script with no verbal interaction delivered by a 2D life-size coach or screened version of it. We assumed that the immersive atmosphere with this hologram-like projection would provide the closest experience to a traditional face-to-face FIT intervention and expected that it would offer an advantage compared to its computerized version. There was no difference in effectiveness of both interventions, 2D and screened, against a control group. Even though the 2D coach elicited slightly more comments regarding its surrealness, both 2D and video screened version of it led to similar evaluations regarding the usefulness of the intervention. This human virtual coach, both 2D and screened, was also considered non-judgemental, showing that not only a robot could prompt this impression on participants.

Overall, the virtual coaches from our four studies, both embodied and screened, human and robotic, evoked positive and negative responses. The main common positive aspect of all of the empirical studies revolved around being given space to talk or think about goals and motivations. The main negative aspect was the lack of personalised response. Another key facet was the perception of virtual coaches as non-judgemental. This theme emerged in Study 2, 3, and 4 with the use of an embodied robot, a screened robot, a 2D human, and a screened video human coach. Study 1 did not elicit this evaluation but it was the only study design that used a webcam to project the participant live. Participants felt self-conscious about seeing themselves on the webcam. Perhaps they perceived the interaction as judgemental—or at least, not non-judgemental—because they were critically judging themselves.

As well as providing answers, these four studies raised questions that can guide the future development of virtual coaches for behaviour change. Even though the quantitative results did not show any difference between the interventions and the control group in behaviour change, the main qualitative findings were that participants found virtual coaches to be acceptable, evoked change talk or mental imagery, and most of them were considered non-judgmental.

Limitations

Study design

Chapter 8 considers design choices in the overall programme of research. In this section, we discuss the extent to which detailed methodological choices help explain contradictory qualitative and quantitative results. Qualitative data from studies 1 and 2 suggested that the technology-led interaction was motivating. Studies 3 and 4 tested this conclusion quantitatively. Unfortunately, they found no evidence of an increase in physical activity, self-efficacy, or goal motivation. This section considers whether the assessment tool or methodology were insensitive to change or whether no change actually occurred.

Based on their own judgement, some participants reported in their qualitative evaluation in Study 1, 2, 3, and 4 that they did engage in more physical activity even though we detected no quantitative differences in actual behaviour change (Study 3 and 4). These findings are summarised in table 9.1. Forty-eight participants receiving MI claimed to have improved their physical activity levels against 18 who did not report change. For those receiving FIT, 48 reported improvements while 45 did not. This result raises the question of whether the virtual coaches impaired the potentials of MI and FIT for behaviour change or the study design failed to capture a change. It also raises questions of why MI seemed to be performing better than FIT when delivered by technology.

Table 9.1: Participants subjective reports on physical activity engagement after the intervention. In Study 1 and 2, participants' reports are from one week after the intervention. In Study 3 and 4, participants' reports are from two weeks after the intervention.

Study and type of virtual coach	**Study 1 Human video coach**	**Study 2 F2F robot**	**Study 3 Video robot**		**Study 4 Human 2D/video coach**
Interval	**One week**	**One week**	**Two weeks**		**Two weeks**
Intervention type	**MI**	**MI**	**MI**	**FIT**	**FIT**
Improved PA	12	17	19	17	14
No change/or worse	6	3	9	14	16

These numbers provide some speculative clues regarding the possible impact of each type of intervention with further testing. There were more self-reported improvements in physical activity levels for MI in comparison with no change than FIT. There could be an advantage of change talk compared to a mental engagement with virtual coaches, but quantitative measures become crucial to test this hypothesis, which did not occur in Study 1 and 2. Study 3's quantitative results did not show any advantage of MI compared with FIT or the control group. FIT might have performed poorly, mainly in Study 4, because of the imagery-only design, which lacks the dialogue that a traditional FIT session provides. Future research would need to test this new dialogue-free FIT in comparison with traditional FIT to test whether there is a loss in effectiveness in face-to-face delivery.

Study duration may contribute to the differences in outcome between the studies. Study 1 and 2 showed higher claimed behaviour change compared with no change than Study 3 and 4. Participants from Study 1 and 2 evaluated the program one week after the intervention whereas those in Study 3 and 4 did so two weeks after it. In Study 3 and 4, participants completed the IPAQ at two weeks. However, the IPAQ instructions are to answer the questions based on activity in the last week. This set up provides no quantitative data on activity in the first week after the intervention. Qualitative data suggest that the benefit of the interventions was short-lived and may therefore have been missed by two-week follow-up. Some participants (Study 3 and 4) reported that they increased their physical activity levels in the first week following the intervention but reduced again in the second week. Others mentioned a boost in motivation that quickly wore off. We intended to capture a more consistent behaviour change with this interval. However, it was not possible to distinguish whether there was a boost in motivation and behaviour change in the week after the intervention that dropped in the second week or whether there was, in fact, a constant unchanged behaviour when compared to a control group. Further trials could measure physical activity repeatedly following intervention, for example using accelerometers, to detect at what point, if any, the virtual MI and FIT intervention have an impact on behaviour.

Not only might the time-span have influenced the results, but the measuring tools as well. Study 3 and 4 used the IPAQ to access physical activity. The IPAQ has been established as an effective tool to measure physical activity (e.g., Craig et al., 2003; Cleland, Ferguson, Ellis, & Hunter, 2018), but it presented drawbacks. Eight participants in Study 3 and 18 in Study 4 had problems in understanding what was requested when filling the IPAQ questionnaire and were dropped from the final analysis. IPAQ has raised problems of interpretation with erroneous distinctions between its domains (occupational, transportation, leisure-time or housework) and also regarding its intensity (walking, moderate or vigorous activity), leading to duplicated answers by participants (e.g., Hallal et al., 2010). Taking the IPAQ prior the intervention might also have influenced the control group. Study 4 showed a slight increase in the IPAQ means of the control group. Becoming aware of one's physical activities might impact subsequent engagement with this behaviour (e.g., Weinstein et al., 1998; van Sluijs et al., 2007). A direct measure of physical activity could potentially give a more precise estimate of the actual physical activity engagement. Measuring physical activity with pedometer showed weak agreement with IPAQ (Colpani et al., 2014) while physical activity estimates also vary substantially measured via self-report or accelerometer (Tucker et al., 2011). However, both pedometers and accelerometers have limitations. Pedometers only measure steps and accelerometers fails to detect some types of physical activity. Nevertheless, being monitored by any objective measuring tool might also influence the control group. There seems to be no ideal methodology of measuring physical activity and we chose the IPAQ for being a well-established cost-effective assessment.

Study 3 and 4 found no effect of intervention on self-efficacy. We predicted that the interventions would increase participants' belief that they would succeed in accomplishing their goals. Our MI and FIT scripts included questions to promote self-efficacy. Furthermore, mental imagery has shown to increase self-efficacy in sports (Karimian et al., 2010; Buck, Hutchinson, Winter, & Thompson, 2016). As cited in Study 3 and 4, the general self-efficacy scale (Schwarzer & Jerusalem, 1995) asks more permanent questions rather than a temporary domain-specific questions. The exercise self-efficacy scale (McAuley, 1993) with time-framed questions specifically about physical activity, could be used in the future for a more sensitive estimate relative to the change we targeted.

As Study 1 and 2 were qualitative, there are still questions remaining regarding the possible effectiveness of these two interventions. There may have been a short-lived effect that the study design failed to detect and which could be boosted by repeating the intervention. A comparison of our automated interventions against face-to-face traditional delivery could elucidate some of the questions regarding the limitations of virtual delivery. Nevertheless, participants' evaluations gave some clues that can direct future research.

Technological adaptation

MI has been effective for a range of behaviours in face-to-face treatment (e.g., Armstrong et al., 2011; Heckman et al., 2010; Lindson-Hawley et al., 2015), including physical activity (Bennett, Lyons, Winters-Stone, Nail, & Scherer, 2007; O'Halloran, Shields, Blackstock, Wintle, & Taylor, 2016; (Kappler & Otterstetter, 2018). Initial tests of FIT in face-to-face deliveries show advantages compared to traditional advice (Andrade et al., 2016). In a controlled trial, FIT has also shown to produce a greater impact in weight loss compared to MI (Solbrig et al., 2018). Shingleton and Palfai (2016), in a systematic review of TAMIs, found that using technology to deliver MI offers a number of advantages compared to face-to-face approaches as to reduce time and resources or the potential for self-disclosure, but that few studies have tested the efficacy of them using control groups. In our studies, we tested the acceptability and efficacy of the virtual coaches delivering MI and FIT in encouraging physical activity, expecting that the automated versions would have some benefit in changing behaviour.

Several limitations emerged in developing the technology-automated interventions. Translating counselling techniques usually delivered face-to-face to different types of technology presents challenges that lead to a series of restrictions when compared to the original mode of delivery. Developing a MI and FIT script for a technological delivery already make them lose some of their full capabilities. Shingleton and Palfai (2016) reported 41 studies in their review of TAMIs with none including all the elements of MI in their intervention. In our MI script, we noticed the difficulty in translating some of the concepts into a virtual delivery. We mainly focused our TAMIs in asking open questions and evoking change talk. Our script adapted to technology was restrained and could have weakened the potential of the virtual delivery. For instance, rolling with resistance or structuring adapted to readiness to change were not possible to include in our format. Other MI elements were more adaptable as strengthening commitment to change or promoting self-efficacy. Not only adapting these interventions into a technological delivery face challenges and limitations, but the technology itself can frustrate participants who expect reactions that they obtain in a face-to-face interaction. One of the constraints often cited by participants was the lack of reflection or feeling understood by the virtual coaches. Even though we tried to mimic a face-to-face dynamic, including an attempted 'listening' part of the interaction, the lack of feedback was an invariable constraint of our virtual coaches.

Given the evidence that traditionally-delivered MI and FIT are effective (Kappler & Otterstetter, 2018; Solbrig et al., 2018), we need to consider explanations for why technology-delivered MI and FIT are not effective. One of the issues emerging from participants' evaluations in Study 3 and 4 was the contrast between feeling motivated and setting goals, to actually acting upon them. Although the interventions seemed to boost motivation, this boost was insufficient to transform thoughts into actions, and it quickly faded. Human delivered may be more effective because human counsellors can use personalised reflection and affirmation to increase empathy and amplify emotions. In MI, there is a notion that a clinician's interpersonal skills (acceptance, egalitarianism, empathy, warmth and MI spirit) facilitate client's collaboration (affect, cooperation, disclosure) (Miller, Moyers, Ernst, & Amrhein, 2003). Moyers et al. (2005) found that therapist interpersonal skills were positively associated with client's cooperation, disclosure, and expressions of affect. FIT also requires the same set of skills by interviewers. Even though FIT works with mental imagery exercises, the face-to-face encounters count on the ability of the counsellor to give the right amount of time for each exercise and support for the client to engage in those exercises, as well as to reflect back the key components of what the participants say. Future empirical studies would need to test our MI and FIT's scripts delivered by virtual coaches against face-to-face delivery by human counsellors to understand whether the adapted scripts were inadequate because they did not allow for reflection or affirmation (because the technology could not respond in this personalised way) or whether delivery by a human is perceived differently even when the intervention they deliver is identical to that delivered by technology.

Despite the assumption that these MI skills are important in FIT, we anticipated that Technology-delivered Functional Imagery Training (TAFIT) would be less dependent on the 'skills' of the interviewer because it focuses more on mental engagement through imagery exercises. In face-to-face delivery, FIT has led to substantially greater weight loss than MI alone (Solbrig et al., 2018). We expected that engaging participants mentally would potentiate technology-delivered MI and also counteract participants' anticipation of personalised feedback. Although participants in studies 3 and 4 positively evaluated having space to think about their goals and motivations, and the opportunity to visualise situations, they still felt the lack of a personalised interaction. This lack was expressed even in Study 4 where the 2D hologram or computer coach only delivered the mental imagery exercises and there was no verbal interaction. Given that participants welcomed the opportunity to speak their goals allowed in studies 1-3, the disappointing results of Study 4 suggest that the focus for future research should be on increasing the extent to which the interaction with technology feels personalised, for example by using a branching script that gives participants more control over the direction of the conversation. Speech recognition capabilities are improving rapidly (e.g., Amazon Alexa, Siri, etc) so an interaction with reflection and affirmation provided by the technology seems an achievable goal for future research.

Implications and future research

The main positive evaluation revolved around the space given to participants to talk out loud with the virtual coaches. Change talk was elicited and observed in every interview in Study 1 with considerably more change talk than sustain talk. The technology employed might have been key to the high instances of change talk as studies of the mechanisms of MI correlate more change talk to therapists MI-consistent skills (e.g., Apodaca et al., 2016; Romano & Peters, 2016). The challenge in developing similar TAMIs with the use of virtual coaches is to sustain the positive room for change talk but possibly enhance its acceptability by decreasing their impersonality. To solve this impersonal perception, participants suggested a branching question design that would lead them into different pathways depending on the answer.

A tailored design, one that leads to personalised feedback, would be one of the possibilities in making the virtual coaches more personal. However, Ryan & Lauver (2002) reviewed the efficacy of tailored informational interventions, which revealed no strong and consistently positive effects comparing tailored with standard interventions. Participants did prefer tailored interventions for being more personal and those also led information to be remembered more than standard ones, but they were more efficient in only half of the total number of studies. A systematic review of the effectiveness of computer-tailored promotion of dietary change and physical activity found that only 3 of 11 physical activity studies but 20 of 26 of nutrition ones showed benefits of tailored interventions versus no intervention or generic information (Kroeze, Werkman, & Brug, 2006). FIT has also been shown to be more effective than MI in weight loss when delivered face-to-face (Solbrig et al., 2018) and this target behaviour could be more promising in virtual delivery than tackling physical activity. TAMIs have shown success in increasing fruit and vegetable consumption and reducing BMI among other behaviours (Shingleton & Palfai, 2016). There is a need to test tech-led interventions in different domains to investigate whether with the same designed intervention leads to different outcomes depending on the target behaviour. Further assessment should tackle whether our virtual coaches would be successful with other behaviours and whether there would be an advantage in a tailored compared to our generalized design.

Another way of tackling the impersonality of eHealth interventions is through 'conversational agents' in the form of chatbots or embodied conversational agents (Laranjo et al., 2018). While chatbots are text-based, embodied conversational agents simulate a face-to-face conversation with verbal and nonverbal interaction. WoeBot and Wysa are text-based chatbots that have been used to deliver self-help programs with personalised interaction. Woebot is a 'conversational agent', used within an instant messenger app, that interacts with the user with responses in words or emoji images (Fitzpatrick, Darcy, & Vierhile, 2017). Their program not only involves the chatbot interaction but also supplementary informational videos and games to teach more about cognitive behavioural therapy (CBT). This intervention reduced symptoms of depression in college students against an informational control group. Wysa is another AI-enabled text-based 'conversational therapist' designed for digital mental well-being, which has also been effective in treating depression (Inkster, Sarda, & Subramanian, 2018). The creators of Wysa called it an 'emotionally intelligent' chatbot. But these text-based chatbots lack the element that we found out in our studies to be important in TAMIs, which is to give space for a verbal interaction.

Regarding spoken conversational agents, there are only a few studies in healthcare other than text-based attempts. Embodied conversational agents, computer-generated characters that simulate face-to-face interactions, are emerging with small qualitative studies showing positive user engagement and involvement but randomised trials are still needed (Provoost, Lau, Ruwaard, & Riper, 2017). Yasavur, Lisetti, & Rishe (2014) developed a spoken embodied conversational system for a brief alcohol intervention. In their study, users felt the system understood what they said even though the virtual counsellor would sometimes not understand the answer, asking the user to repeat what they said, or move on to a next question. In Lisetti, Amini, Yasavur, & Rishe's study (2013), users reported an intention by over 30% to use an intervention delivered by a spoken-based embodied conversational agent over a text-only system. In a systematic review of conversational agents—text and spoken based—with unconstrained natural language in healthcare, Laranjo et al. (2018) detected that there are only a few studies published. They are mainly quasi-experimental and rarely evaluate efficacy. These conversational agents require large training datasets, which Laranjo et al. (2018) suggest as being one of the reasons to their slow adoption in health applications. DeVault et al. (2014) showed that AI-based speech and gesturing still lacks important human qualities. They created an AI virtual human interviewer and compared it with a Wizard of Oz scenario. Even though users reported a positive general satisfaction for both options, the AI system showed more inappropriate nonverbal behaviour and was considered a worse listener than when a human was controlling the virtual agent. TAMIs and TAFITs with a conversational agent would require a large training datasets for unconstrained natural language that is convincing to participants. While technology does not reach a comparable face-to-face therapeutic engagement, a solution could to combine elements of text and speech recognition for a tailored interaction.

Another way for developing a more personal interaction comes from participants' suggestion of complementing these virtual interventions with a health professional, combining face-to-face sessions with remote ones. Blended treatments use face-to-face counselling methods in combination with online care to obtain an optimal benefit of both modalities, offering possibilities of personalized mental health care treatment with the potential cost-effectiveness and accessibility of virtual delivery (Wentzel et al., 2016). Erbe, Eichert, Riper, & Ebert's (2017) systematic review results suggest that blended treatment compared with face-to-face therapy may save clinician time, lead to lower dropout rates, or help maintain achieved changes. But they also point out that there is a lack of comparative studies with internet-based treatments. Complementary to the idea of a blended model, participants also expressed the need for a more frequent interaction. Vandelanotte et al. (2007) detected in a website-delivered review of physical activity interventions that studies with greater contact, more than five communications, led to more positive outcomes. In a systematic review on maintenance of behaviour change following physical activity interventions, Fjeldsoe et al. (2011) highlighted the importance of follow-up prompts to achieving maintenance. Solbrig et al.'s (2018) trial in which FIT outdid MI, there were two face-to-face sessions plus booster calls every two weeks for three months with the frequent contact mostly likely being crucial for the efficacy of the intervention.

While the impersonality of the virtual coaches frustrated participants, this neutrality might have contributed to participants' positive evaluation of the technology as non-judgemental in studies 2, 3, and 4. Our results suggest that virtual coaches might offer benefits compared to face-to-face interactions due to a non-judgemental nature. Joinson's studies (2001) showed that self-disclosure is higher in computer-mediated communication than face-to-face with visual anonymity possibly being implicated in this effect. This non-judgemental evaluation, raised spontaneously by participants in the qualitative arm (in Study 2, 3, and 4) of this research, reveal the apprehension they feel of being judged in social or therapeutic interactions. Invisibility in online environments gives people the courage to express themselves they would not otherwise with physically invisibility amplifying the disinhibition effect (Suler, 2011). And our virtual coaches from Studies 2, 3, and 4 substantiate this potential for self-disclosure.

Virtual coaches might be particularly useful when there is negative, shame-related information, or conditions with a stigma attached to it.

Technological advanced assessment in the forms of audio, computer, and video produced greater risk disclosure for HIV patients compared to traditional methods (Gerbert et al., 1999; Caldwell & Jan, 2012). Face-to-face interviews elicit underreporting of socially undesirable behaviour as alcohol consumption than a computer (Waterton & Duffy, 1984). Undergraduate business students preferred to reveal sensitive information that were more likely to evoke negative self-admission in an interview to an avatar as they would not judge them while for low sensitivity topics or that would evoke positive self-admission they would prefer to reveal to human interviewers (Pickard et al., 2016). Thus, not only self-disclosure can vary accordingly to the type of technology, but also to the valence of information to be revealed. In health, patients withhold medically relevant information from their clinicians with the most commonly reported reason for nondisclosure not wanting to be judged or lectured (Levy et al., 2018). Our virtual coaches have the potential of breaking through this initial fear of being judged and provide a tool for openness, potentially being useful in healthcare.

This type of virtual coaching could be used not only to encourage behaviour change but instead to gather information that would not be revealed to a human being. This asset could also be particularly useful with specific medical populations. Robots have been used in therapeutic treatment of autism spectrum disorder (ASD) children. Adolescents on the autistic spectrum demonstrated lengthier disclosures to robots compared to typical developing controls compared to interacting with a human interviewer (Kumazaki et al., 2018). Our studies collaborated with established research by demonstrating that this non-judgemental facet could be raised with both embodied and screened virtual coaches, humans and robots. Further developments of this research should investigate this non-judgemental effect using virtual coaches, how different types evoke self-disclosure and how to refine them in a way that they are useful in a clinical setting.

Study 1 was an exception because participants did not mention this non-judgemental aspect of the interaction. We might attribute this difference to use of webcam, which participants criticised. Videoconferencing has been implemented in psychotherapy, associated with good user satisfaction and similar clinical outcomes to face-to-face delivery (Backhaus et al., 2012). Even though we expected that most participants would be familiar in interacting through video chat platforms such as Skype or FaceTime—as also used in videoconferencing counselling,‒most of them reported feeling uncomfortable or distracted seeing their own image reflected live. In Howell et al.'s study (2016), individuals with elevated social anxiety, in live webcam interaction, avoided eye contact and had negative self-evaluations, which seems what also happened in our intervention.

Another interpretation for the higher reported self-consciousness is that participants recruited wanted to increase their physical activity levels. It might also probably be the case that the majority did not feel comfortable about their own body shape or lifestyle, also reinforcing their self-consciousness. Body-related shame mediates the relationship between body weight and self-esteem (Pila, Sabiston, Brunet, Castonguay, & O'Loughlin, 2015). Overweight women reported feeling self-conscious about their looks as a cognitive barrier to engaging in physical activity while healthy-weight women reported functional barriers as lack of equipment (Napolitano, Papandonatos, Borradaile, Whiteley, & Marcus, 2011). The webcam might have reinforced the self-consciousness that some participants already had. The use of this technological tool might be useful in cases in which participants do not have an issue about their self-image. Future research should investigate further the use of webcam in interactions with virtual coaches in order to understand mechanisms of self-consciousness induction with and without this function, and whether this tool can be beneficial in some cases or should indeed be avoided.

Our interventions did not require high eHealth literacy for engagement, that is, owning a set of skills to be able to work with technology aimed at health promotion (Norman & Skinner, 2006). With a straight forward interface, these virtual coaches, both embodied and screened, could serve to distinct purposes. The physical robot (Study 2) evoked more comments about the surprising experience, which was the first time most participants had seen a robot in close proximity. There was no difference when evaluating the delivery of the intervention with physical (Study 2) and screened robot (Study 3), both eliciting a similar amount of reported benefits. However, we did not directly compare physical and video versions of the robot intervention. There is some evidence that physical robots are more persuasive and perceived more positively than telepresent robots (projected on a computer screen) (Li, 2015). Physical robots also prompt higher empathetic responses than their virtual representations (Paiva et al., 2017). However, Fasola and Matarić (2013) compared a physically present robot to a screened version of it for encouraging physical activity and detected that the interaction with the embodied robot was rated higher in enjoyableness, helpfulness, and social attraction, but resulted in similar levels of task performance. In a study with children, an embodied robot also elicited a higher interaction, but both physical and screened versions were successful in engaging them in motor activities (Fridin & Belokopytov, 2014). Our studies showed the same pattern: participants seemed more excited about the interaction with the embodied version but both physical and screened robot elicited similar comments about the effects of the intervention itself. The results from our studies demonstrated that a screened robotic version, which is cheaper and more accessible could lead to similar acceptance and possible effectiveness as a physical robot.

The unique interplay with a robot led some participants to report their experience outside of the lab, telling friends and family. The excitement of such interaction reflected the desire to comment about the interview, potentiating the repercussions of such experience. Reaching others could also reinforce a social commitment for changing one's behaviour. Making goals public results in higher commitment (Hollenbeck, Williams, & Klein, 1989). And making a commitment leads to a higher probability that individuals will execute the action (Kiesler, 1971). Study 2 shows that a robotic motivator has the potential of producing a social echo as participants reach other human beings to, not only narrate their experiences, but also to reveal their motivations and plans, reinforcing their commitment. Future research should test the prediction that this 'social echo' leads to behaviour change. It would also be interesting to study these conversations about the robot interview, for example to measure change talk during the initial interaction (as we did in Study 1 with the human videocounsellor) and study if subsequent conversations about the interaction repeat and amplify that change talk.

Besides testing a physical robot as a coach, we used a hologram-like projection for the first time as a health tool, opening up the possibility for further explorations in the area. Participants evaluated our 2D hologram-like human coach from Study 4 mostly positively. Others had a more neutral or slightly negative experience. In our study, while the embodied and screened versions shared reports about being 'interesting', 'enjoyable', or 'calming', the embodied form led to extra set of words in describing the experience as 'surreal', 'captivating', 'unusual', or 'intriguing', which did not appear with the screened versions, potentially being more remarkable. Even though the 2D coach evoked slightly stronger reactions than its computer screened version, participants reported a similar level of interaction and benefits than the computerized form. This result replicates the lack of difference we found between physical and video robots, discussed in the previous section. As far as I am aware, Luévano and colleagues (2015) are the only team of researchers using this technique. They reported that, in an education setting, 65% of students stated paying more attention to the professor on this 2D projection than using a telepresence robot. Further studies could test whether participants might be more likely to develop a 'relationship' with an embodied coach than a screened version of it with repeated sessions.

There was a risk that the 2D coach could have fallen into the 'uncanny valley', in which people's evaluation of a humanlike representation shifts from empathy to revulsion as the representation approaches human appearance but fails to replicate it perfectly (Mori, 1970). This problem did not arise: there were more positive comments about the 2D coach's appearance than negative. While screened virtual coaches are more affordable and could potentially reach a greater number of people, the physical versions of both the robot and human videocounsellor seem to have the potential of being more remarkable. We launched this technological tool for motivational support and further research becomes necessary to determine health areas in which this hologram-like coach could be useful.

Each virtual coach might be used for reaching different type of public. The screened versions of the virtual coaches as opposed to their embodied versions might reach a greater number of people who could access this technology from a home computer, laptop, iPad, or mobile phones. Automated MI and FIT might also reach a different public. The mental-only engagement makes this type of intervention helpful in cases in which a verbal interaction would not be possible as, for instance, on a mobile phone in a train. The embodied versions that we explored in the form of a physical robot and 2D coach might be useful in healthcare as an intervention people could undertake in a waiting room before an appointment, for instance. The video doctor in Humphreys, Tsoh, Kohn, & Gerbert's study (2011) increased the likelihood of women to reach a healthcare provider. An embodied virtual coach, for being more remarkable, might even be more effective in encouraging patients to seek further assistance.

One could envision AI developing in a way that would achieve a comparable interaction as in face to face with improved speech recognition and personalised feedback. With advancements of AI and technological formats, these automated counsellors can achieve much more in the time to come than they are able to accomplish in the present moment. Regardless of possible technological advancements, virtual coaching should be used not to replace human beings, but to work together with them, each bringing their best resources in order to help others. Our virtual coaches offered a series of benefits as accessibility, potential for change talk and self-disclosure, and their non-judgemental asset that could offer a cheap health tool with even some advantages compared to traditional counselling.

Conclusions

We developed an array of MI-based interactions with technology with a spoken dialogue between the technology and human participant. Kanaoka & Mutlu (2015) seem to have developed the only other spoken-based dynamic TAMI, which used a physical robot. Our dynamic MI expanded their previous work by using also a human video coach and a video robot besides a physical robot without using imprecise artificial intelligence, but a fixed schedule of questions and a period for answering that was under the participant's control. We implemented the first technology-based dynamic FIT intervention with the use of a video robot and human 2D coach plus a video coach. The hologram-like, 2D coach, debuted in health research in our studies. Technologies develop at a quick pace, leading virtual interventions to become dated rapidly (Baker et al., 2014). Our studies focused on using technology in novel ways to elicit dialogue and imagery from the participant rather than specificities about technological development that might become outdated. Even though our virtual coaches have bumped into many limitations and obstacles, they have shown potential in several domains.

We detected that there is a dilemma between giving space to participants to talk or think freely about their behaviour and giving back a personalised response. Participants liked the unconstrained space to talk and think, but wanted personalisation which, with currently technology, would have meant to constraining how they could respond. Giving space to participants, besides evoking change talk and mental engagement, may have led to one of the main assets of our interventions, which was the non-judgemental nature of both embodied and screened, human and robotic, virtual coaches. The absence of perceived judgment by these virtual coaches can invite openness and self-disclosure. This perception was not expressed by participants when the webcam was present, which induced many to be more self-conscious. There is also an impasse between the novel experience—how participants engaged with this technology on a first encounter—and the suggestion that there should be a more frequent interaction with the virtual coaches to increase the impact of the interventions. The initial excitement in being interviewed by a physical robot showed potential for leading to a social reverberation and social commitment. We still need to learn how best to use the positive features that our virtual coaches can offer for effective behaviour change.

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APPENDICES

Appendix 2.1

MI Video Coach Sample

https://vimeo.com/319021878

password: mivideo

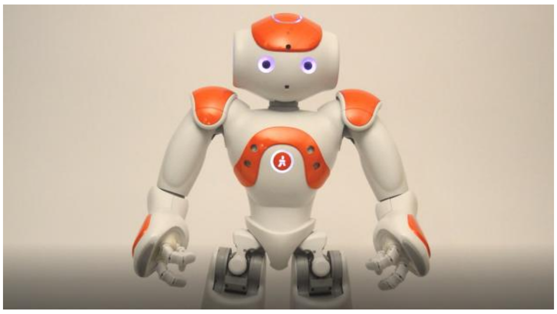
Appendix 2.2

MI Video Coach 'Listening' Sample

https://vimeo.com/319028418

password: listening

Appendix 2.3



MI Video Robot Sample

https://vimeo.com/319023150

password: mirobot

Appendix 2.4

FIT Video Robot Sample

https://vimeo.com/319028989

password: fitrobot

Appendix 2.5

2D Coach Prototype Sample

https://vimeo.com/319019706

password: 2dprototype

Appendix 2.6

FIT Video for 2D Projection Sample

https://vimeo.com/319029774

password: fit2d

Appendix 3.1

Motivational Interviewing script presented by video-counsellor

Welcome to this video interview!

Please find a quiet place to do this interview, where you won't be overheard when you answer my questions out loud. Please also turn off your phone, so you won't be interrupted.

After you answer each question, you will need to press the button below to proceed to the next question.

Take your time to give a complete answer. The more you work on your answers, the more you can get out of this interview.

____

I understand that you are considering changing your behaviour, and you've already taken the first step by taking part in this video interview.

So, is it OK if we talk about that now? (2 sec pause).

Thanks. During this interview, sometimes I may ask you questions that you think you've already answered. If that happens, I suggest you use it as an opportunity to think about the issue a bit more. Let's get started.

What have you been thinking about doing?

____

Why have you been thinking about doing that?

____

If you made this change, how will that affect other areas in your life?

____

What improvements might you notice in the first few days?

____

Let’s put it this way--What may happen in the future if you don’t change anything?

____

Does that worry or concern you? ...Why?

____

Would everything else concern you if you keep doing things the way you are doing them?

____

Try summarising the things that are likely to get better if you change your behaviour.

____

When you think about that list of things, how does it make you feel?

____

OK—so, thinking about all the things that may get better if you made these changes, which is the most important one to you right now?

____

Why is that important to you now?

____

So, in thinking about all this, what goal might help you get these positive changes?

____

Let's see if we can make this as specific as we can—what steps would you need to take, and when. What would be the first step?

____

Let's focus on your confidence in getting started.

How confident are you that you can carry out this plan for the next week? Give it a rating from 0, not at all confident, to 100%, really confident.

____

Tell me about a time in your life when you had been doing better than you are now...

____

Can you remember other times that you did better?

____

Could you do something similar now?

____

Are there other times you've succeeded in changing your behaviour in the past—even for a short time?

____

Thinking about the things you did in the past to help you reach your goal, are there any strategies you could apply over the next week?

____

Are there other things you could do now, to help you get started?

____

Is there anyone who could help you over the next week?

____

Think about how you'll carry out your plan over the next week. Chances are it will be a bit harder at some times than others. Is there a time in the next few days that may be a bit harder? Tell me about that.

____

What could you do, to make sure you follow your plan over the next week?

____

Sounds like a plan.

OK, let's redo your confidence rating.

How confident are you that you can carry out your plan for the next week? Remember, the rating scale goes from 0, not at all, to 100%, really confident.

____

Was your second rating a bit higher than the first one? Just thinking about a time you succeeded in the past, and how you did it, can often increase your confidence.

You don't have to be 100% confident to get started—you just need enough confidence to take the first step. Give it a go!

I suggest you summarise what you are going to do, why you want to do it, and what makes you confident you can at least do it for a week. What will you do? Why? And what makes you confident you can get started.

____

That's great. You may find it useful to write that down. If you need a bit of a boost to your motivation over the next few days, you could try reading that over to remind yourself about what you said.

All the best with your plans!

Appendix 3.2

Sample first page of change/sustain talk coding sheet

Participant ID:

Q1 What have you been thinking about doing about your behaviour?

A1: "Taking up swimming …I can."

Category	**Change talk**	**Sustain talk**
Commit	**X**	
Desire		
Ability		
Reason		
Need		
Taking Steps		
Other		

Q2 Why have you been thinking about doing that?

A2: "I think I need to do more exercises to feel healthier."

Category	**Change talk**	**Sustain talk**
Commit		
Desire		

Ability		
Reason	**X**	
Need	**X**	
Taking Steps		
Other		

Q3 If you made this change, how will that affect other areas in your life?

A3: "None that I can think of."

Category	**Change talk**	**Sustain talk**
Commit		
Desire		
Ability		
Reason		**X**
Need		
Taking Steps		
Other		

Appendix 4.2

Qualitative questionnaire

1. How was your experience during the robot interview?
2. How was your interaction with the robot?
3. How engaging did you find the interview with the robot?
4. How connected did you feel with the robot?
5. How was your understanding of each question? Was the content clear?
6. In case you had problems in understanding a question, do you remember which ones?
7. Did you answer all the questions? In case you didn't, explain why and which question.
8. How were your feelings during the interview with the robot?
9. How was your mood in the day you had the interview with the robot?
10. How did you feel about hearing yourself talk about your goals out loud?
11. How important do you think it was listening to yourself out loud discussing your behaviour?
12. Were the instructions regarding the robot interview clear?
13. How did you find the robot's interface? Was it easy or difficult to use?
14. Did you get frustrated at any point during the interview? Why?
15. Would you use a robot like this in future to help you keep motivated?
16. What's the best aspect of this robotic interview for you?

17. What's the worst aspect of this robotic interview for you?
18. How do you think the robotic interview could be improved?
19. Have you tried other motivation techniques before?
20. What helps you the most in staying motivated?
21. What is the hardest part in keeping yourself motivated?
22. Did this interview with the robot affect your motivation? How?
23. Have you adopted any strategy to motivate yourself in the past week?
24. Did you improve your physical activity after the robot interview? How?

Appendix 6.1

Goal Motivation Scale for Physical Activity Questionnaire

Goal Motivation Scale for Physical Activity-Strength

Thinking about increasing your physical activity, please select a number on each row to answer these questions.

Right now…

1. How strongly do you want to do it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
2. How strongly do you feel you need to do it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
3. How strong is your urge to do it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
Right now, how vividly can you											
4. … imagine yourself doing it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
5. ...imagine how you would do it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
6. … imagine how good it would be to do it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
7. … picture times you did something like this in the past?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
8. …imagine succeeding at it?	0	1	2	3	4	5	6	7	8	9	10

	Not at all										Extremely
9. … imagine how much worse you'll feel if you don't do it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
Right now…											
10. How much are other things reminding you about it?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
11. How much are thoughts about it grabbing your attention?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely
12. How easily can you keep it in mind?	0	1	2	3	4	5	6	7	8	9	10
	Not at all										Extremely

1. The draft GMS-PAS had a further imagery item: "*…imagine how much better you'll feel if you do it.*"

Items 1-3 form the **Intensity** subscale; Items 4-9 **Imagery**; Items 10-12 **Availability**.

Goal Motivation Scale for Physical Activity-Frequency

Thinking about increasing your physical activity, please select a number on each row to answer these questions.

Over the last week, how often did you…											
1. …feel you wanted to do it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
2. …feel you needed to do it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
3. …have a strong urge to do it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
Over the last week, how often did you…											
4. …imagine yourself doing it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
5. ...imagine how you would do it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
6. ...imagine how good it would be to do it?	0	1	2	3	4	5	6	7	8	9	10

	Never										Constantly
7. ...picture times you did something like this in the past?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
8. ...imagine succeeding at it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
9. ...imagine how much worse you'd feel if you didn't do it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
Over the last week, how often…											
10. ... did other things remind you about it?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
11. ... did thoughts about it grab your attention?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly
12. ... did thoughts about it come to mind?	0	1	2	3	4	5	6	7	8	9	10
	Never										Constantly

Items 1-3 form the **Intensity** subscale; Items 4-9 **Imagery**; Items 10-12 **Availability**.