Design and evaluation of simulated reflective thoughts in virtual reality exposure training

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Dissertation

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"If there is light in the soul, there will be beauty in the person.

If there is beauty in the person, there will be harmony in the house.

If there is harmony in the house, there will be order in the nation.

If there is order in the nation, there will be peace in the world."

– Confucius, 551–479 BC

To my beloved family.

Contents

Summary

Social skills are important for people to advance in life. Therefore, social skills training has obtained considerable attention. Both traditional and digital methods exist to improve people's performance in social interaction. Among these approaches, social skills training systems that use technologies such as mobile applications, robots, and virtual reality, play an important role. Frequently, these training systems impart knowledge and information to users or provide them with opportunities to learn by doing or by observing. In this thesis, we propose and investigate a novel training method that aims at simulating the thinking process by providing people with an artificial stream of thoughts (i.e., virtual cognitions) that they may experience during social interaction. Through this approach, users will not only learn what they should do and how they should do it, but also understand why they should behave in a certain way. Moreover, the method also aims at stimulating users' beliefs about their capabilities of engaging in social interaction, i.e., their self-efficacy. The main research question of this thesis, therefore, is: how can we develop a virtual reality exposure system with virtual cognitions that affect people's behaviour and beliefs during the training, and what impact does such a system have on its users afterwards?

The first step in addressing this research question was conducting a systematic literature review of the state-of-the-art in technology-based social skills training systems. A total of 122 studies (with 113 systems) was identified, classified, and analyzed to find potential opportunities and gain inspirations for

designing and evaluating social skills training systems. The results suggested that most of the training systems were screen-based applications, with virtual reality technology being the most frequently observed. From a functionality perspective, the review found that support for learning-by-doing was the most observed function in these systems. Although the studies reported overwhelmingly positive results regarding the systems' impact, most studies only used a quasi-experimental design based on self-report measures.

The systematic review showed that most of the existing systems only work as a platform for users to learn by doing, without informing them why they should behave in a certain prescribed way. The aim, therefore, was to extend these traditional systems with virtual cognitions that would provide this information. Consequently, the next step of the research was to investigate how these cognitions could be delivered. As our virtual cognitions intend to mimic, to some extent, an individual's inner voice, we investigated its sound parameters by letting people simulate their inner voice. Taking into account that people's inner voice relates to their outer voice, the work explored people's perception of their simulated inner voice by considering several core sound parameters of their outer voice. Participants were invited to set key sound parameters to match their own voice recordings with their perception of either their own inner or outer voice. The results indicated that people's sound perception was different between inner and outer voices. Also, individual variations were found for the perception of inner and outer voice differences. After examining these sound parameters, the concept of an artificial inner voice was used to create virtual cognitions for training. The guidance we wanted to provide through virtual cognitions was letting people have (1) the appropriate information to deal with the current situation; (2) the ability to interpret the current situation; and (3) enough confidence and willingness to continue dealing with the upcoming situation. Hence various types of virtual cognitions were identified. For example, those that offered information on a topic, reflections on the current situation, motivational encouragement, and instructions.

The following part of the research focused on whether virtual reality social skills training with virtual cognitions combined with simulated speech could affect people's beliefs and behaviour. For this, two empirical studies were conducted. The first was a pilot study that followed a pretest-posttest design, without a comparison group. It established the feasibility of the system. As the results were promising, it justified a more extensive study to control for confounding variables. The second study, therefore, was set up as a randomized controlled trial. Besides studying the effectiveness of the system, it examined the impact of self-motivational statements included in virtual cognitions. The results showed that virtual reality social skills training with virtual cognitions significantly increased people's self-efficacy and enhanced their knowledge about negotiation, while self-motivational statements even further improved self-efficacy. Furthermore, these effects remained after multiple weeks.

After establishing the general effect of the training system and the impact of different types of virtual cognitions, the work moved on with investigating the effect of matching virtual cognitions with people's visual attention. Access to a broad range of sensory cues could promote the sense of presence in virtual reality, especially when multiple sensory stimuli are synchronized with each other. This idea was examined in the final empirical study. It compared virtual exposure with eye-gaze adaptive virtual cognitions and with non-eye-gaze adaptive virtual cognitions. The findings indicated people's eye-gaze behaviour was more likely to follow instructions embedded in eye-gaze adaptive virtual cognitions than non-eye-adaptive virtual cognitions. Additionally, eye-gaze adaptive virtual cognitions had a positive effect on people's perceived ownership of the virtual cognitions.

In summary, this thesis demonstrates the possibility of generating virtual cognitions that simulate the thinking process that people might have. The findings show that providing virtual cognitions in virtual reality can affect people's beliefs and behaviour. Moreover, adapting the virtual cognitions to an individual's eye-gaze can have a guiding effect on their eye-gaze behaviour. These studies together outline the blueprint for not only a novel, but also

a quite promising training method that improves people's self-efficacy and operationalizes theoretical knowledge concepts in the setting of a realistic scenario.

Samenvatting

Sociale vaardigheden zijn belangrijk voor mensen om verder te komen in het leven en daarom heeft het ontwikkelen van sociale vaardigheden aanzienlijke aandacht verworven. Er bestaan zowel traditionele als digitale methodes om mensen te helpen bij het verbeteren van hun sociale interacties. Bij deze methodes spelen trainingssystemen een belangrijke rol, waarbij gebruik wordt gemaakt van technologieën zoals mobiele applicaties, robots en virtual reality. Deze trainingssystemen brengen vaak kennis en informatie over aan gebruikers of stellen gebruikers in staat om te leren door te doen of door te observeren.

In dit proefschrift stellen we een nieuwe trainingsmethode voor, en onderzoeken we deze. De trainingsmethode heeft tot doel het denkproces te simuleren door het bieden van een kunstmatige gedachtestroom (d.w.z. virtuele cognities) die mensen zouden kunnen ervaren tijdens sociale interactie. Door deze aanpak leren gebruikers niet alleen wat ze zouden moeten doen en hoe ze zouden moeten handelen, maar leren ze ook waarom ze zich op een bepaalde manier zouden moeten gedragen. Bovendien richt deze methode zich ook op het stimuleren van de overtuigingen in hun eigen vermogen om deel te nemen aan sociale interactie, dat wil zeggen hun zelfeffectiviteit ("self-efficacy"). Daarom is de hoofdonderzoeksvraag van dit proefschrift: hoe kunnen we een virtual reality systeem met virtuele cognities ontwikkelen die het gedrag en de overtuigingen van mensen tijdens de training beïnvloeden en welke impact heeft zo'n systeem na gebruik op gebruikers?

De eerste stap in het beantwoorden van deze onderzoeksvraag was het

uitvoeren van een systematisch literatuuronderzoek om een overzicht te krijgen van de stand van de techniek van trainingssystemen voor sociale vaardigheden. Er werden in totaal 122 studies (met 113 systemen) geïdentificeerd, geclassificeerd en geanalyseerd om potentiële kansen te vinden en inspiratie op te doen voor het ontwerpen en evalueren van trainingssystemen voor sociale vaardigheden. De resultaten suggereerden dat de meeste trainingssystemen schermgebaseerde applicaties waren, waarbij virtual reality-technologie het vaakst voorkwam. Functioneel gezien bleek uit de review dat ondersteuning voor 'leren door te doen de' meest voorkomende functie was in de systemen. Hoewel de studies grotendeels positieve resultaten rapporteerden met betrekking tot de impact van de systemen, gebruikten de meeste studies alleen een quasi-experimenteel ontwerp op basis van zelfrapportagemetingen.

Uit het systematische literatuuronderzoek bleek dat de meeste bestaande systemen alleen fungeren als een platform voor gebruikers om te leren door te doen - zonder hen te informeren over de redenen waarom ze zich op een bepaalde voorgeschreven manier moeten gedragen. Het doel was daarom om deze traditionele systemen uit te breiden met virtuele cognities die deze informatie zouden verstrekken. Daarom was de volgende stap om te onderzoeken hoe de virtuele cognities geleverd konden worden. Omdat onze virtuele cognities tot op zekere hoogte de innerlijke stem van een individu beogen na te bootsen, hebben we de geluidsparameters onderzocht door mensen hun innerlijke stem te laten simuleren. Rekening houdend met het feit dat de innerlijke stem van mensen betrekking heeft op hun uitwendige stem, verkende dit onderzoek de perceptie van mensen van hun gesimuleerde innerlijke stem door verschillende basis geluidsparameters van hun uitwendige stem te variëren. Deelnemers werden uitgenodigd om deze geluidsparameters in te stellen om hun eigen stemopnames te matchen met hun perceptie van hun eigen innerlijke en uitwendige stem.

De resultaten gaven aan dat de geluidsperceptie verschillend was voor de innerlijke en uitwendige stem. Er werden ook individuele variaties gevonden voor de perceptie van verschillen in de innerlijke en uitwendige stem. Nadat

de geluidsparameters waren vastgesteld, werd het concept van de innerlijke stem gebruikt om virtuele cognities voor de training te creëren.

De begeleiding welke we via virtuele cognities willen bieden, bestaat uit mensen de juiste informatie geven om (1) met de huidige situatie om te gaan, (2) het vermogen te krijgen om de huidige situatie te interpreteren, en (3) voldoende vertrouwen en bereidheid te ontwikkelen om door te gaan met de aanstaande situatie. Daartoe werden verschillende soorten virtuele cognities geïdentificeerd. Voorbeelden hiervan zijn het bieden van informatie over een onderwerp, reflecties op de huidige situatie, motiverende aanmoedigingen en instructies.

Het volgende deel van het onderzoek richtte zich op de vraag of virtual reality sociale vaardigheidstraining met virtuele cognities in combinatie met gesimuleerde spraak de overtuigingen en het gedrag van mensen zou kunnen beïnvloeden. Hiervoor werden twee empirische onderzoeken uitgevoerd. De eerste was een pilotstudie die een pretest-posttest ontwerp volgde zonder controlegroep. Dit stelde de haalbaarheid ("feasibility") van het systeem vast. De resultaten waren veelbelovend en rechtvaardigen een uitgebreider onderzoek waarbij de invloed van mogelijke alternatieve verklaringsfactoren worden geminimaliseerd.

De tweede studie was daarom opgezet als een gerandomiseerde gecontroleerde studie. Naast het bestuderen van de effectiviteit van het systeem onderzochten we ook de impact van zelfmotiverende verklaringen in virtuele cognities. De resultaten toonden aan dat virtual reality sociale vaardigheidstraining met virtuele cognities de zelfeffectiviteit van mensen significant verhoogde en hun kennis over onderhandelen verbeterde, terwijl zelfmotiverende virtuele cognities de zelfeffectiviteit nog verder verbeterden. Bovendien bleven deze effecten na meerdere weken bestaan.

Na het algemene effect van het trainingssysteem en de impact van verschillende soorten virtuele cognities te hebben vastgesteld, ging de studie verder met het onderzoeken van het effect van het afstemmen van virtuele cognities op de visuele aandacht van mensen. Toegang tot een breed scala

aan sensorische signalen zou het gevoel van aanwezigheid in virtual reality kunnen bevorderen, vooral wanneer meerdere sensorische stimuli met elkaar worden gesynchroniseerd.

Dit idee werd onderzocht in de laatste empirische studie. Deze studie vergeleek virtuele cognities die inspelen op het kijkgedrag (adaptieve virtuele cognities) met virtuele cognities welke geen rekening houden met het kijkgedrag. De resultaten laten zaten zien dat mensen vaker de instructies ingebed in de virtuele cognities volgden wanneer deze inspeelden op het kijkgedrag. Bovendien hadden deze adaptieve virtuele cognities een positief effect op de beleving dat dit gedachtes waren van de persoon zelf.

Samenvattend laat dit proefschrift de mogelijkheden zien van het genereren van virtuele cognities die het denkproces simuleren. De bevindingen laten zien dat het verschaffen van virtuele cognities tijdens de virtuele ervaring de overtuigingen en het gedrag van mensen kan beïnvloeden. Bovendien kan het afstemmen van de virtuele cognities op de kijkrichting een leidend effect hebben op het kijkgedrag van de individu. Deze studies schetsen samen de blauwdruk voor een nieuwe en veelbelovende trainingsmethode die de zelfredzaamheid van mensen verbetert en theoretische concepten operationaliseert in de setting van een realistisch scenario.

Chapter

1

Introduction

1.1 Motivation

Social interactions fill our daily lives, a tracking survey conducted by Mehl and Pennebaker [1] estimates that people spend between 32% and 75% of their waking time on social interactions. Social skills can affect academic achievement and peer acceptance in childhood [2], as well as job performance and salary in adulthood [3]. A report released by the Pew Research Center indicated that from 1985 to 2015, the number of jobs in the US labour market that requires strong social skills increased by 83%, from 49 million to 90 million [4]. Although social interactions are so common and important, it can be quite challenging for people to manage them well [5, 6]. In the UK, the overall annual loss of production due to expected social skills deficits is anticipated to reach 8.4 billion pounds per year by 2020 [7]. Difficulty with social interaction can also become pathological; for example, people that suffer from a social anxiety disorder. This is one of the most common anxiety disorders, with a lifetime prevalence estimate as high as 9.3% for the Dutch population [8] and 12.1% for the US population [9].

Given the impact of weak social skills on everyone's daily life, various self-help books have been published [5, 10, 11] and courses have been given [12–14] to help people in dealing with this disorder. In recent years, a large number of social skills training systems have also emerged. Although these training systems are recognised as beneficial thanks to their accessibility and low cost [15–19], several limitations undermine their efficacy. First, their goal is usually to offer people opportunities to practice or to impart knowledge. While the former aims at creating simulated training and learning scenarios, the latter focuses on teaching people what to do and how to act. However, these systems do not help people in operationalising the theoretical concepts and principles they learned into a realistic situation [20]. Second, training systems often neglect the importance of the individual's own motivation and willingness to engage in social interaction. This, however, has been highlighted as an essential component of social skills [21]. Fortunately, there are strategies

to improve people's beliefs about their capabilities, i.e. their self-efficacy, thus increasing their motivation and willingness to engage in social activities [22]. For example, according to social cognitive theory [23], people's self-efficacy can be affected by four factors: mastery experience, vicarious experience, verbal persuasion, and emotional and physiological states. Among them, mastery experience is often regarded as the most effective factor because it provides direct evidence of one's capabilities [24, 25]. However, mastery experience comes with a risk: it can also expose a person to failure experiences, which can lower one's self-efficacy. One way to tackle this problem is to provide guidance in the form of appropriate instructions, explanations, or reflections. Not only could this guidance affect people's understanding of how to act, but also the way they perceive the process and result of the experience - and both of these aspects could lead to a successful experience in the end.

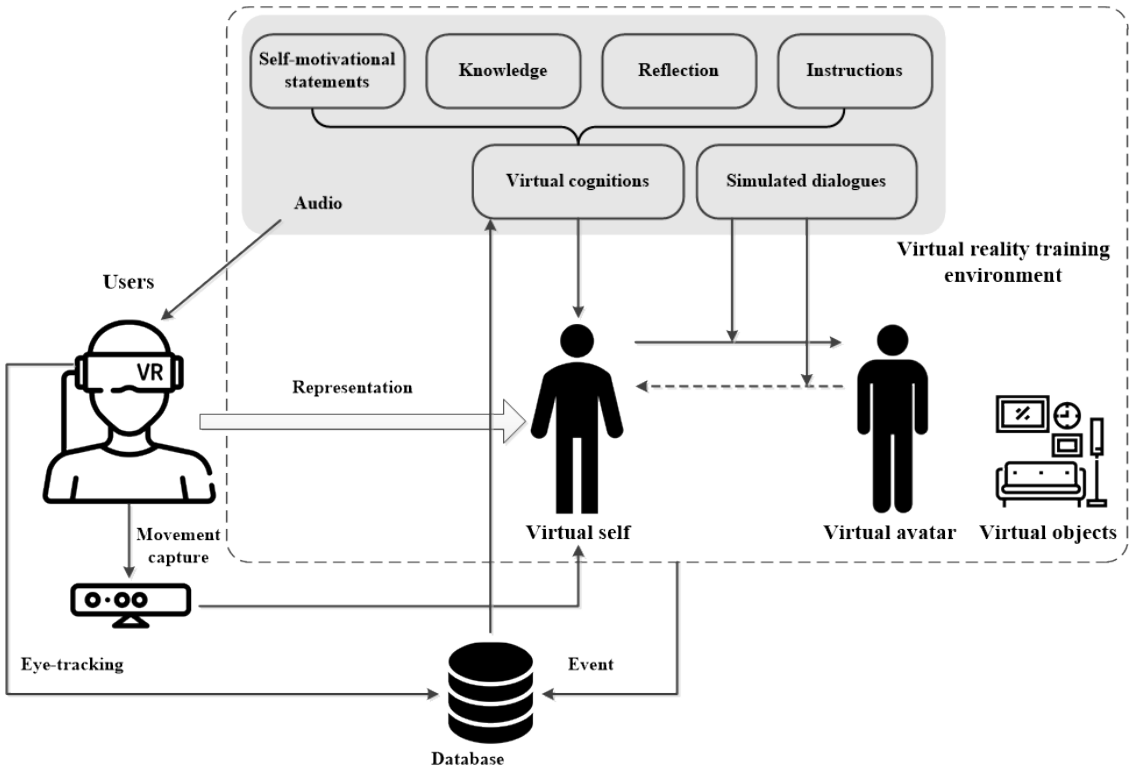

Figure 1.1: The framework of the training system

Thus, our vision, as shown in Figure 1.1, is to let people explore social interactions, both perceptually and cognitively, from a first-person perspective.

The perceptual experience is achieved through a virtual reality environment. The cognitive experience is realised in the form of virtual cognitions, i.e. a stream of thoughts that simulates the thinking process during social interaction (e.g., a simulated inner voice [26]). Virtual cognitions consist of guided learning and motivating statements. We believe that a virtual experience with virtual cognitions can enhance people's knowledge of managing social interactions, improve their ability to operationalize this knowledge into a realistic scenario, and perhaps most importantly, increase their self-efficacy.

Virtual Reality (VR) exposure has been studied for several years, showing beneficial outcomes for different kinds of training and therapies [27–29]. A major part of the research and development focused on evoking rich perceptual experiences (such as presence and immersion) with advanced visual and auditory displays, and haptic and tactile feedback [30–33]. Incorporating virtual cognitions into the VR-environments is an interesting opportunity to evoke cognitive experiences for further advancement of the training. The development of virtual cognitions like inner voices for such a purpose is yet a rather unexplored research area.

1.2 Main Research Question and Hypothesis

The following main research question has driven the research presented in this thesis:

How can we develop a virtual reality exposure system with virtual cognitions that fosters people's behaviour and beliefs during the training, and what impact does such a system have on its users afterward?

From this research question, one sub-question and four hypotheses were derived. Taken together, they provide an answer to how we should create these virtual cognitions, adapt them to the system, and to what extent the system can affect people's behaviour and beliefs. This section elaborates on the positions taken in this thesis and how they are supported by previous research.

In the past decades, a large number of social skills training systems have been developed to improve people's social skills. Many technologies have been employed, such as a robot, serious game, video modelling, and virtual reality [34]. Many social skills have been targeted by these systems, for instance, public speaking, job interview, negotiation, and so on [19, 35, 36]. These systems also provide various functions to offer different interventions, such as role-playing, imparting knowledge and modelling, etc. Owing to this variety of systems, before developing a new one, it is necessary to first get an overview of the state of the art of technology-supported social skills training systems. Therefore, this thesis first examines how the existing studies worked in designing, developing and evaluating training systems, following the first sub-question presented below.

Question 1: What kind of social skills training systems have already been developed and what are they composed of?

Although the literature reports on a variety of social skills training systems, these systems seem to focus exclusively on skill development. They typically teach learners what to do or how to behave during social interaction in a learning-by-doing manner. Although feedback is provided, to the best of our knowledge, no system exists that informs learners in real-time about the reasons as to why they should behave in a certain prescribed way. The latter would be beneficial for learners as thoughtful and timely guidance could be vital for the effectiveness of the learning experience [20]. Besides understanding, little attention has been paid to people's beliefs about their own capabilities, e.g. their self-efficacy, which determines how they feel, think, behave, and motivate themselves to participate in social interactions [37]. This thesis envisions a system that focuses on people's understanding of social interaction and self-efficacy, allowing people to explore social interaction, both perceptually and cognitively, from a first-person perspective. The cognitive experience is realised in the form of virtual cognitions, i.e. a stream of thoughts. It works as a kind of inner voice, simulating the thinking process

during social interaction [26]. In order to provide such virtual cognitions, knowing how to simulate the inner voice is essential.

It should be noted that the sound characteristics of one's inner and outer voice seem to be dissimilar but related. Much research shows that there is a link between inner and outer voices. For example, Vygotsky et al. show that the inner voice is the result of a gradual internalisation of the outer voice [38]. Likewise, Filik and Barber suggest that a person's inner voice resembles their outer voice, even down to the regional accent [39]. Therefore, one way to simulate the inner voice is to consider several core sound parameters of one's outer voice. Although the inner voice seems to have a close relation, even similarities, with the outer voice, Brocklehurst and Martin [40] also found that stuttering people believed their inner voice as not stuttered, which means a person's inner voice might hold different sound characteristics from their outer voice. Given these considerations, this thesis hypothesises that:

H1. People perceive their inner voice to sound different from their outer voice.

According to social cognitive theory [23], mastery experience and vicarious experience can alter people's self-efficacy. In the context of negotiation training, this thesis takes the stance that virtual cognitions can provide guidance and instructions to enhance the mastery and vicarious experience, thus affecting a user's self-efficacy. It allows users to passively experience how a successful negotiation process unfolds from a first-person perspective. It provides a source of information that imparts knowledge of negotiation, reflects on the situation at hand, and explains why they should behave in a certain way. For virtual cognitions, we will focus on the simulation of speech that can evoke the vicarious experience of the "inner voice". This thesis hypothesises that virtual reality negotiation training with virtual cognitions combined with simulated dialogues can enhance people's negotiation knowledge and self-efficacy, leading to hypotheses 2:

H2. Virtual reality negotiation training with virtual cognitions

combined with simulated dialogues improves negotiation knowledge and self-efficacy of negotiation compared to no training.

Next to mastery and vicarious experience, people' s self-efficacy can also be affected by verbal persuasion [23]. This thesis focuses on persuasion in the form of self-motivating statements that can foster people's self-efficacy. Many studies support the effectiveness of self-motivating statements. For example, reading aloud positive self-statements increased people's self-esteem and decreased feelings of inadequacy [41], and even helped to relieve depression [42]. Moreover, Hatzigeorgiadis et al. [43] indicated that using motivational self-talk can increase people's self-efficacy and even enhance their performance in tennis. Therefore, this thesis hypothesised that adding one more component - self-motivating statements - to virtual cognitions can verbally persuade people, thus further improving their self-efficacy. This leads to hypothesis 3.

H3. Virtual cognitions with self-motivational statements improve self-efficacy more than virtual cognitions without self-motivational statements.

Although providing virtual cognitions during virtual reality exposure could provide several benefits to users, it also provides an additional source of information that requires attention, which brings new factors into play, including selective attention and divided attention. One way to monitor a user's attention is through tracking eye-gaze movement [44]. This thesis takes the stand that synchronising virtual cognitions to users' eye-gaze can enhance the effectiveness of the instructions embedded in virtual cognitions on their behaviour. Wickens et al. [45] suggest that when exposed to multiple and incongruent sources, people might be forced to divide their attention across multiple information sources, which imposes additional cognitive load that interferes with their experience. Whether people select, focus and process the content of virtual cognitions determines whether and to what extent they affect people's behaviour. If virtual cognitions are coherent with other stimuli, people might be able to pay more attention to their content, and consequently,

follow up on instructions embedded in virtual cognitions, for instance, "Try to look at the spider a bit longer". Based on these considerations, this thesis hypothesises that:

H4. People's eye-gaze behavior is more likely to follow the instructions embedded in eye-gaze adaptive virtual cognitions than non eye-gaze-adaptive virtual cognitions.

1.3 Research approach

The first research question, exploring the state of the art of technology-based social skills systems, was studied through conducting a systematic review in this field. Following a comprehensive search and two-rounds of screening, 122 publications with 113 systems were identified, characterised and analysed to identify potential opportunities and gain inspirations for the design and evaluation of social skills training systems. What we derived from this review served a starting point for the next step. More details can be found in Chapter 2.

To test the first hypothesis, an empirical study that explored people's perception of their simulated inner voice and outer voice was conducted. Using specially developed audio recording and modification software, 15 participants set key sound parameters to match their own voice recording with their perception of either their own inner or outer voice. They modified seven sound parameters of the recordings: pitch, speed, echo, and volume with the frequency band (20-320Hz, 320-1280Hz, 1280-5120Hz, and 5120-20480Hz). More details and results can be found in Chapter 3.

The second hypothesis was tested in an experimental setting, with a waitlist design. 48 participants were recruited and randomly assigned to two conditions: a waitlist group and a training group. First, they were asked to make voice recordings, modify the sound parameters and complete an online questionnaire collecting demographic information and pre-test measures. The pre-test measures consisted of questions regarding self-efficacy, negotiation

performance and behaviour, self-esteem, as well as a negotiation knowledge test. After that, the participants in the training group were given the virtual reality negotiation training with virtual cognitions consisting of three consecutive sessions. Meanwhile, the participants in the waitlist group were not given any negotiation training. All participants were asked to fill in online questionnaires that measure their negotiation self-efficacy and complete a negotiation knowledge test both before and at the end of the experiment. The study and the corresponding results are described in detail in Chapter 4.

The third hypothesis states that virtual cognitions with self-motivating statements have a positive effect on people's self-efficacy, compared to virtual cognitions without self-motivating statements. This hypothesis was also tested in an experimental setting, simultaneously with the last experiment, but in a between-subject design. After recording, modification and completing the questionnaires, using the same procedure as the above study, 48 participants received the training with virtual cognitions, either with or without self-motivating statements. After the training, participants were asked to complete the questionnaires and tests that measure their self-efficacy of negotiation, negotiation knowledge, negotiation behaviour and performance, and the utility of the system. More information can be found in Chapter 5.

The final hypothesis was also tested in an empirical study. To explore the effect of adapting virtual cognitions to individuals' eye-gaze, exposure with eye-gaze adaptive virtual cognitions were compared with exposure with non eye-gaze-adaptive virtual cognitions in a within-subjects experiment ($n = 24$). In the non-adaptive condition, participants heard randomly chosen virtual cognitions, while in the other condition, participants were exposed to the virtual cognitions adapted to participants' eye gaze to steer their attention toward or away from the animals in the virtual world. During the exposure, the system automatically counted the number of eye-gaze shifts participants made after hearing the instructions embedded in virtual cognitions. After each exposure, participants completed a questionnaire about their perception of plausibility and their sense of ownership of virtual cognitions. The study

and its findings are presented in detail in Chapter 6.

Chapter 7 presents a general discussion and conclusion drawn from the various studies in this thesis. Moreover, this chapter also puts forward a reflection and suggestions for future research based on the limitations and contributions of this work.

Chapter

2

Technology-supported social skills training systems: A systematic literature review

2.1 Introduction

Social interactions permeate every aspect of our life as they occupy a considerable part of most people's waking life [1]. Unfortunately, for some, it is challenging to function well in situations such as public speaking [46], negotiations [5] and job interviews [47]. Social skills impediments can have various negative impacts. It can hamper peer acceptance and academic achievement for children, bring about vocational difficulties for adults, cause an economic loss for organizations, and even lead to life-threatening situations for soldiers [48]. Extreme examples of people with difficulties are those with social phobia or autism spectrum disorder. Given the impact of social interaction on everyone's daily life, self-help books [49, 50] and face to face training [51] have been developed. For clinical cases such as social anxiety disorder, various therapies have also been proposed, including social skills training (SST), cognitive-behavioural therapy (CBT) or even medication [52]. Typically a teacher or a therapist performs this conventional social skill training in person. The access is often mainly limited to people with serious disabilities or the elite, owing to their high cost [53]. Furthermore, creating adequate and controlled social interaction is difficult [54]. Since they carry the promise of cost-effectiveness and controllability, it is not surprising that researchers have flocked to study technology-supported systems for social skills training and therapy. In the past decades, a wide range of systems have been reported in the literature, applying a variety of technologies, including but not limited to immersive virtual reality (VR), augmented reality, robots, and screen-based software. Although the number of such systems and studies is considerable, state of the art about them seems still unclear.

This chapter aims to present an overview of technology-supported social skills training systems from the scientific literature. Previous reviews can be categorized into three main types. First are the reviews that focus primarily on the treatment methods or theories underlying therapy for social skills [55–58]. They do not take a system or technology perspective. Second are the reviews

that describe social skills training only applying a specific technology, such as virtual reality or robots [59–61]. Third are the reviews based on social skills training systems but targeting a specific group, such as children with autism [58, 62–64].

This study intends to cover various technologies, to target a wide range of audiences and skills, to consider both treatment- and therapy-oriented training systems, as well as both general teaching- and practice-oriented training systems. To the best of our knowledge, this is the first survey with this particular scope. There are several merits to be discussed. First, this study can serve as a state of the art overview of the field. Consequently, this chapter could be a starting point for readers looking for future research directions or answers to questions regarding state of the art. For example, questions about which technologies, skills, and target audiences are most actively being studied? In addition to this, the chapter outlines what functions are often included in these systems, and how these systems are evaluated.

To this end, this chapter addresses the following three research questions:

1. How have these systems been developed? e.g., which types of technologies have been used? Which group of population or social skills do these systems target to most?

2. Which functions do these systems provide and how do they relate to the different applied technologies, target skills and target groups?

3. What is the overall perception of the efficacy of these systems on social skills training?

2.2 Methods

2.2.1 Search procedure

A systematic review was conducted using Scopus and Web of Science, two widely used abstract databases. The search query consisted of three major components: 1. targeting social skills, 2. describing a technology-supported system with the purpose of training, 3. reporting an empirical evaluation of

the system. The list of search terms for the social skills concepts included synonyms for social skills, such as social capability, and social competence, as well as terms for specific common social skills, for example, public speaking, interview skills, or negotiation. The search terms for technology-supported systems included synonyms and common technologies, such as computer aided, computer based, virtual agents, and mobile applications. Appendix A shows the detailed search queries. Reviews, surveys and meta-analysis papers were excluded as the last step. The search for English language publications was first conducted on October 02, 2017 and then updated on December 16, 2018.

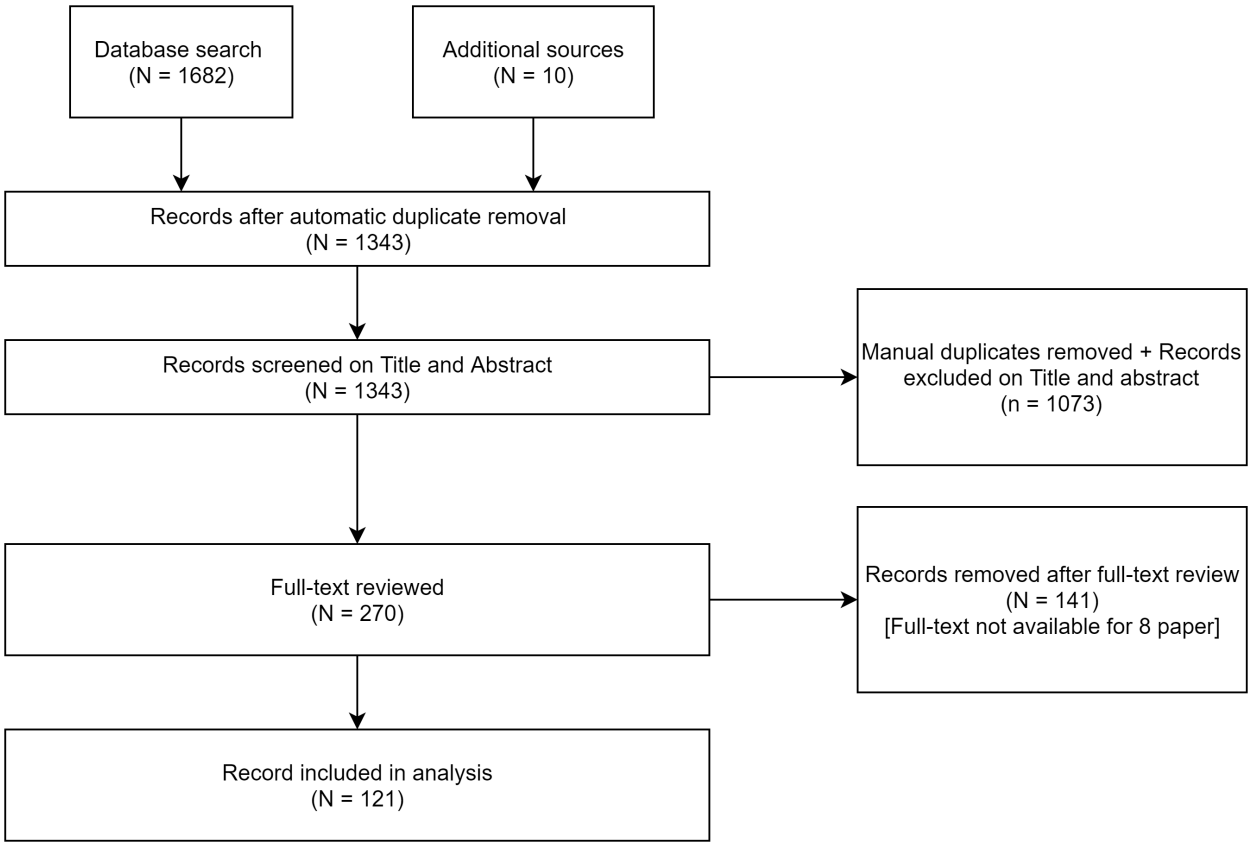

Figure 2.1: PRISMA-Diagram for the filtering process

The search resulted in a total of 1682 conference papers, journal articles, and book chapters. Reference lists of the included papers were checked for potential papers; it resulted in 10 further papers. After automatically removing the duplicates, 1338 papers remained for further selection.

As shown in Figure 2.1, a two-step review was carried out: screened based

on the title and abstract and screened based on the full-text version of the papers. There were two coders active in this study. At each step, a coder performed the entire review while the other coder served as a control to determine inter-rater agreement. The control consisted of a random subsample of records that were double coded. The inter-observer agreement was calculated using a Kappa-metric [65]. For the selection based on title and abstract, a random sample of 400 papers was used for the double coding, resulting in an agreement of 0.91. For the second round, a random sample of 50 papers was used, resulting in an agreement of 0.98. Both showed acceptable levels of reliability and were considered sufficient to move on to the next step of selection.

2.2.2 Inclusion Criteria

We included articles that: (1) were available and accessible in a full-text version of the paper, written in English, (2) included a technology-supported system with the purpose of (3) training social skills, and (4) described an empirical study.

For criterion (2), all types of digital medium were included (i.e. iPads, Computers, Head-mounted displays, Robots). Systems could also have a human component. Regarding criterion (3), the training is not limited to therapy or treatment but also includes general teaching, education or practice. Furthermore, the training could target a behaviour, cognition or motivation related to social interactions [66].

2.2.3 Exclusion Criteria

Simply providing information in a digital format was not considered sufficient (e.g. a normal curriculum, but just online [67]). Also, papers about entirely human-based training were excluded (e.g. [68]). Furthermore, as a training system, they should offer something extra in terms of experience or interactions (e.g. excluding [69]). Moreover, systems that were solely used to measure or test skills were excluded (e.g. [70]). As for criterion (4), to

ensure that systems were actually developed and functional at some point, papers that did not include an experimental or observational evaluation of the training systems were excluded (e.g. [71]).

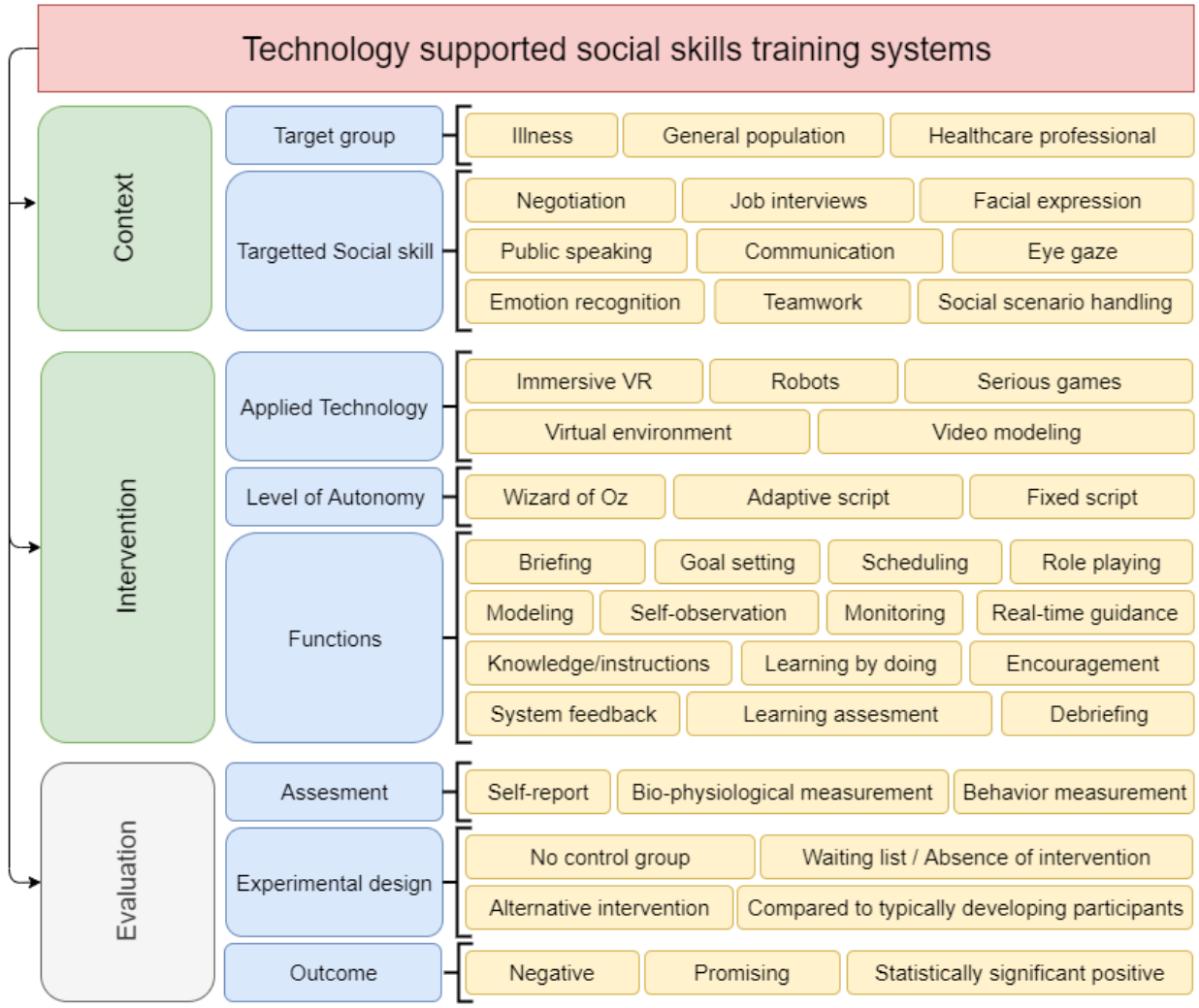

Figure 2.2: Taxonomy of technology-supported social skills training system

2.2.4 Coding

Figure 2.2 shows the taxonomy used for coding the data extracted from the papers. Each block represents a core concept related to the training system and the evaluation of it. The blocks have attributes, addressing the characteristics of each system and the evaluation. General information about

the system such as system name, authors, year of publication, the reported location of the study etc. was collected directly from the paper.

As shown in Figure 2.2, eight attributes were collected to categorize systems and to obtain a better comprehension of the social skills training systems. They are the technologies applied by the system, the target group of the system, the target skills of the system, level of autonomy of the system, functions provided by the system, the types of assessment used in the experiments, experimental design, and the results of the experiments. Most attributes are self-explanatory. Some need some further clarification.

A crucial task in the coding process was identifying the training system by functional elements, i.e., functions. Functions were the building blocks that made up the interventions of the training system, e.g. a function that allowed users to role-play an interviewee attending a job interview. The functions considered were chosen from both classical therapy and teaching methodologies [55, 72, 73]. Figure 2.2 shows a list of the functions. Note that these functions were only considered when the technology-supported system provided them and not when the external environment, e.g. a human, embodied them. For instance, when a person at the start of training gave the user a thorough explanation, it was not regarded as a function of the system.

Secondly, the systems were categorized into four types based on the technology employed. A distinction was made between immersive virtual reality, robots, screen-based applications and a remaining category for other technologies. The screen-based application category was again subdivided into three popular paradigms: serious games, virtual environments/agents, and video modelling. Thirdly, the level of autonomy attribute illustrates the autonomous level of the system. It was categorized into three types: Wizard-of-Oz, Fixed scripts, and Adaptive scripts. Wizard-of-Oz is a popular paradigm for designing social skills training systems. When interacting with a Wizard-of-Oz prototype, people believe the system operates autonomous, where, in fact, an unseen human operator fully or partially controls the system. With fixed script systems, all users received a similar pre-defined system response.

With an adaptive script, on the other hand, the system's response depended more on users' input. Often this required the use of either some database or artificial intelligence algorithms. Fourthly, the evaluation design attribute, four types were considered depending on whether the intervention group was compared with: a waiting list, an alternative intervention, typically developing (TD) person, or no control group.

2.2.5 Statistical Analysis

We conducted a descriptive analysis with R version 3.4.2. All the review data, the R scripts, and output files can be found online[1].

2.3 Results

Tables in appendix B show the records of the technology-supported social skills training systems that the review examined. Sometimes the same version of a system was used in multiple studies, but with unique experiments [74–77]. In these cases, all studies were included in the table, while only one system was counted. If multiple papers presented the same version of a system with the identical experiment(s), only the latest record was included. In total, the review identified 122 studies (121 papers, one paper has two studies, the references for all papers are provided in appendix C.) describing 113 systems. Coding these systems on their key attributes led to the characterization presented in Table 2.1.

2.3.1 Systems, versions and basic attributes

Systems had 1.05 versions on average, while more than 96.3% only had one. Therefore, most systems seem to have been one-offs without being part of a long-term scientific improvement cycle. Only four systems had two or

[1]These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is `10.4121/uuid:ee7efb66-cef8-49c8-9a1e-383e47d58e09`.

more versions, for example, the "Automated social skills trainer" with three versions [15, 78, 79].

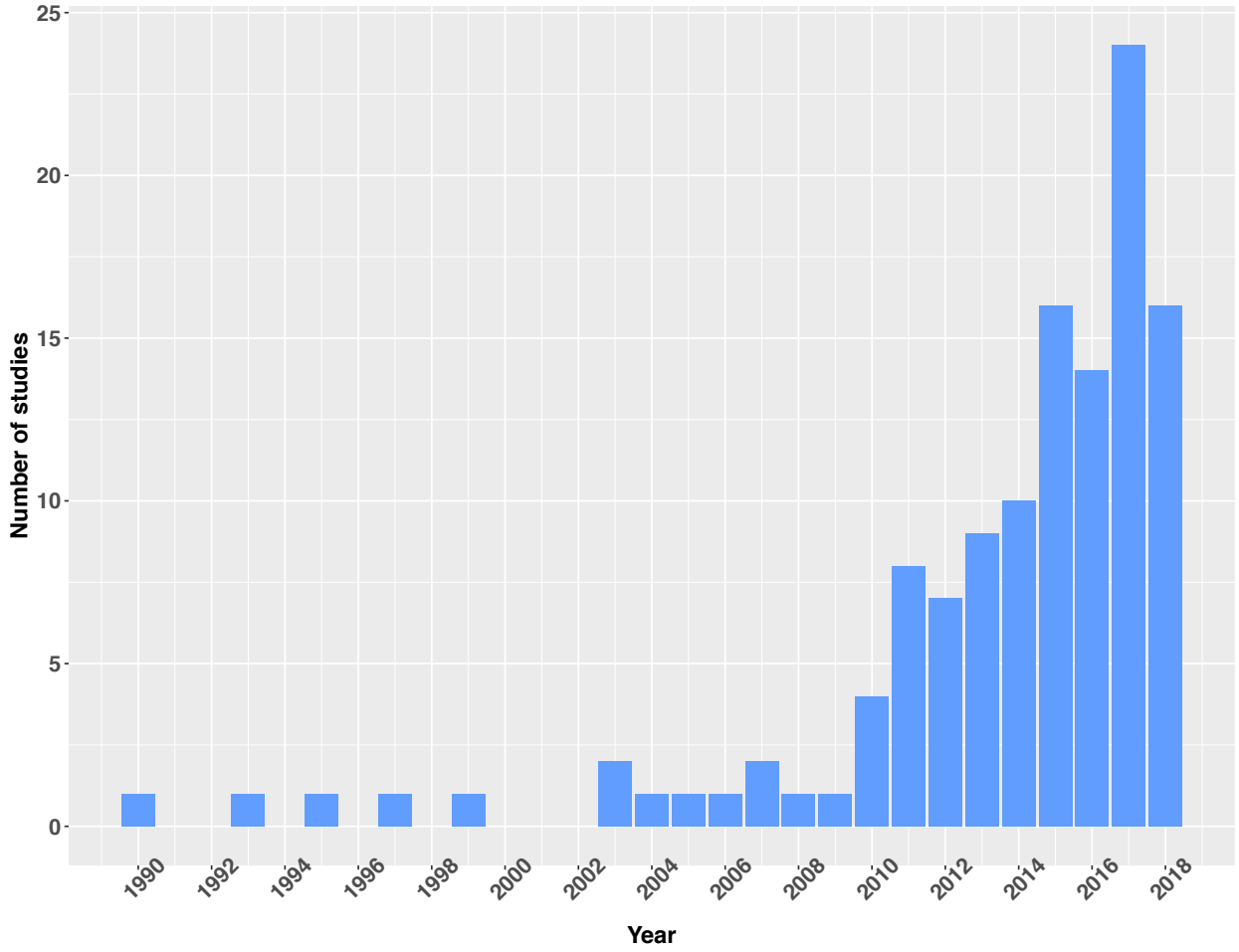

Figure 2.3: Distribution of records over the years.

The investigation also looked at where the research was carried out. If this was not explicitly stated in the paper, the first author's institution location was taken. North America was responsible for about half of the studies. Moreover, the USA, China, The Netherlands, UK and Israel were the top 5 contributors.

Furthermore, the review examines how the number of published studies changed over time. A gradual increase of papers over the years is shown in Figure 2.3. The figure shows a drop for 2018. Likely, the searched abstract databases might not have included all published 2018 papers at the time of the investigation. The data shows a different uptake in technology adoption.

Both for immersive VR and screen-based VR, an increase in papers is visible (Figure 2.4), with the former lagging behind the other. The recent trend of more affordable VR equipments might explain this.

2.3.2 Technologies applied and target group

As shown in Table 2.1, the most common type of system for social skills training is a screen-based system (71.7%, 81/113). Among them, the virtual environment was most often used (28.3%, 32/113). Nevertheless, in respect of a specific technology, virtual reality technology that covers both immersive virtual reality (20.4%, 23/113) and virtual environment (28.3%, 32/113), also accounted for almost half of the systems. Other types of technology were

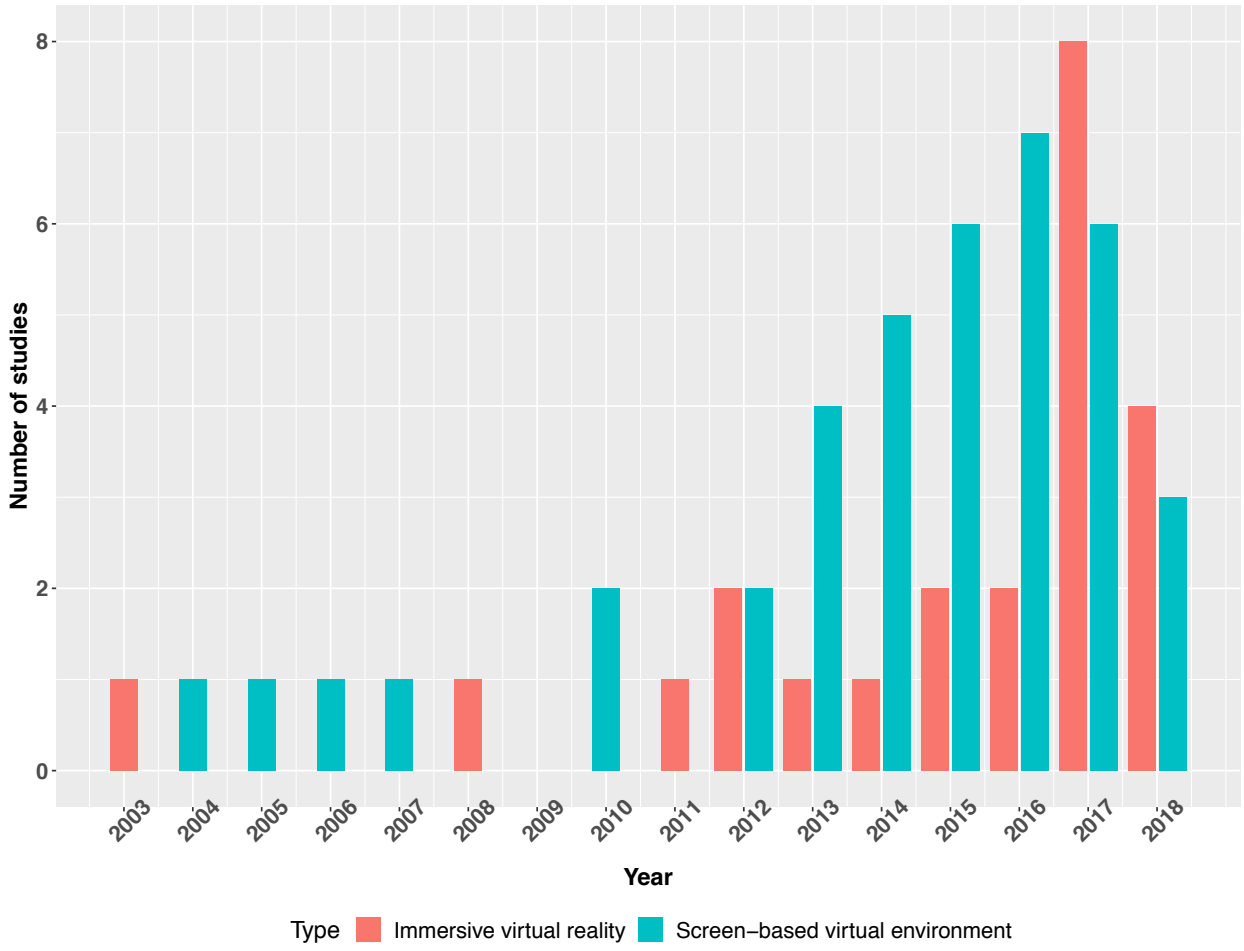

Figure 2.4: Evolution of immersive VR vs Virtual Environments

serious games (18.6%, 21/113), robots (8.0%, 9/113), and video modelling (4.4%, 5/113).

Of the 113 systems, 59.3% (67/113) were aimed at people with a specific medical or psychological disorder. Among these, people on the autism spectrum were the most common (73.1%; 49/67), and 67.2% (45/67) of these systems target children specifically. Besides this, about a quarter of the studies were targeting the general population (23.9%; 27/113). Finally, another popular target audience was health-care professionals. Understandably, a large number of health care jobs rely on patient interaction. As can be seen in Table 2.1, 15.0% (17/113) of the systems targeted health care professionals.

2.3.3 Target skills

The most common targeted skill of the training systems is communication (38.1%, 43/113), with the rest divided fairly evenly over skills like negotiation (7.1%, 8/113), job interviews (7.1%, 8/113), public speaking (10.6%, 12/113), and facial expression (12.4%, 14/113), etc. Another finding is that 66.4% (75/113) of systems focused on macro skills, compared to 11.5% (13/113) and 22.1% (25/113) for micro and a combination of both respectively. Evidently, systems often targeted skills like public speaking, job interviews, and negotiation holistically, instead of choosing to focus on specific elements such as eye contact and emotion recognition.

2.3.4 Size and functionality

The average system offered 3.11 functions ($SD = 1.13$) with a range from one to seven. There is a considerable difference between the most and the least frequently provided functions. Four functions that are provided often in classical therapy or conventional therapy-oriented social skills training [80] seemed to appear less often in the technology-supported systems. These are briefing (1.8%, 2/113), scheduling (0.9%, 1/113), goal setting (0.9%, 1/113) and debriefing (0%, 0/113). For most cases, the whole training program still might have offered these functions; however, a person might have carried them

Table 2.1: Distribution of key attributes

	%		%		%		%
Applied technology		Job Interviews	7.1	Scheduling	0.9	Biophysiological measurement	3.3
Immersive VR	20.4	Communication	38.1	Role playing	63.7	Other	8.2
Robot	8.0	Eye gaze movement/eye contact	15.0	Modeling	22.1		
Screen Based		Facial expression	12.4	Self-Observation	7.1	**Experimental control**	
Serious Game	18.6	Emotion/facial/body language recognition	15.0	Monitoring	6.2	Yes(absence of intervention)	22.1
Virtual Avatar	28.3	Teamwork/shared decision making	4.4	Real-time guidance	4.4	Yes(compared to alternative)	10.7
Video Modeling	4.4	Social scenario handling	13.3	Imparting knowledge/Instructions	54.0	Yes(compared to TD person*)	2.5
Other	20.4	Other	26.5	Learning by doing	90.3	No (single group)	64.8
				Encouragement, praise and rewarding	23.9		
Target group		**Level of Autonomy**		Performance feedback and reflection	34.5	**Results of experiment**	
Illness	59.3	Wizard of Oz	8.8	Learning assessment	0.9	Positive (Statistically significant)	59.0
Healthcare professional	15.0	Adaptive interaction	10.6	Debriefing	0	Positive (without statistically support)	38.5
General Population	23.9	Fixed interaction	71.7			Negative (Statistically significant)	0.8
Other	1.8	Other	8.8			Negative (without statistically support)	1.6
Targeted Social Skills		**Functions**		**Assessment**			
Negotiation	7.1	Briefing	1.8	Self-report	63.9		
Public speaking	10.6	Goal setting	0.9	Behavior observation	48.4		

*TD person: Typically developing person

out, e.g., a trainer that provided the debriefing. Consequently, the review did not count them as system functions. On the other side of the spectrum, functions like learning by doing (90.3%, 102/113), role-playing (63.7%, 72/113) as well as imparting knowledge (54.0%, 61/113) seem much more popular.

Moreover, by looking at the number of functions used when targeting a certain social skill, we found the systems focusing on facial expression to provide the largest number of functions ($M = 3.6$, $SD = 0.8$), while the systems targeting the teamwork and shared decision-making skills provided the fewest functions ($M = 2.2$, $SD = 0.8$). Besides, from the perspective of the target group, the average number of functions provided by systems targeting clinical population, health-care professional, and the general population was 3.1, 2.9, 3.3, which was quite close to each other. Nevertheless, except these three typical population, the systems targeting the other population offered much fewer functions ($M = 2.0$, $SD = 0.0$). When investigating the number of functions provided by the systems employing different technologies, the systems employing video modelling technology were designed with the largest number of functions ($M = 4.4$, $SD = 1.1$).

2.3.5 Evaluation

2.3.5.1 Assessment

The most used form of assessment for the studies included in this review was self-reporting (63.9%, 78/122). This included reports about their experience, anxiety, self-efficacy, and social skills. Another common form of assessment was behavioural observations (48.4%, 59/122). Bio-physiological measurements (3.3%, 4/122) were less frequently reported. They included measurements like blood pressure, heart rate, and stress-levels through skin conductance.

2.3.5.2 Experimental design

The majority of the experiments described in the study were quasi-experiments (71.3%, 87/122). Often the evaluations did not include a follow-up

assessment (80.3%, 98/122). Still, 19.7% (24/122) of the studies had a follow-up assessment. Among them, 58.3% (14/24) were done within four weeks; while 25% (6/24) of the studies measured after more than half a year. The average sample size of the studies was 34.8 participants, ranging from 2 to 421 participants; respectively, 22.4 participants for studies with a single-group design, 27.8 participants per group for the studies with a comparison or control group. A considerable number of these studies might have been underpowered when considering a 5% level of significance, 80% statistical power to detect at least a large effect size (0.80 Cohen'd) [81,82]. Only 17.7% of the studies with a single-group design, and 27.9% of the studies with a multi-group design seems to have had an adequate sample size, taking a group size of 28 [1] and 26 [2] as the cutoff respectively.

2.3.5.3 Results of experiments

Table 2.1 shows that 97.5% of the studies suggested that the system had a positive impact. 59.0% (72/122) reporting a statistically significant positive or improvement result, while 38.5% (47/122) indicated the system shows promise without underlying hypothesis testing support. Only 2.5% of studies reported negative results, from which one study based on statistical hypothesis testing. Of the studies that had a randomized controlled trial design, 85.7% (30/35) reported statistically significant positive or improvement results on measures such as conversational skills rating scale [83] and liebowitz social anxiety scale [84].

2.4 Discussion and Conclusion

This study proposed a taxonomy, which researchers can use to position their work. Furthermore, in line with the research questions, the findings allow

[1] Group size is based on a significant test for a product-moment correlation coefficient with a large effect size (Cohen 1992) [81].

[2] Group size is based on a significant test for difference between two independent sample means with a large effect size (Cohen 1992) [81].

for three main conclusions. Firstly, although the review found that social skill training systems use a variety of technologies, two-thirds of the systems were screen-based applications; from which, virtual reality was studied most frequently. The most targeted social skill for these training systems was communication skills, with more than one-third of the systems developed to train it. Secondly, the function learning-by-doing was provided by most of the systems. Besides, the systems focusing on facial expression provided the largest number of functions, while the systems employing video modelling technology were designed with the most functions. This indicates that these systems were the most extensive. Finally, 97.5% studies reported the systems to have a positive impact, such as improving people's feeling, cognitions, emotions or behaviour. Among these studies, there were 30 studies with a randomized controlled trial design that reported statistically significant improvements.

Besides the above, there are some other interesting findings. The review found a continuous growth in the number of systems developed each year. Evidently, research into these systems is still ongoing and attracting more momentum. The application of technologies such as robots [85], augmented reality [86], and combination of virtual reality and brain-computer interfaces [87] seem the latest to attract attention in this field. Besides technology diversification, a broadening of the target audience is also possible, as most systems in the review focused on a clinical population targeting people with social anxiety and autism. While the review found systems targeting health care professionals, it also found systems that target other professions such as software engineers [88], law enforcers [89], and crisis managers [90]. Potentially, more jobs that depend on social skills could benefit likewise.

Additionally, developers can also extend on the system's functionality. Only one-third of the systems provided feedback functionality, despite meta-analysis research [91] having identified that receiving feedback on one's performance as one of the essential components in social skills training, next to practising. Similarly, the function, "positive reinforcement", which includes encourage-

ment, praise and rewarding is critical for achieving a positive impact on the improvement of social skills [92]. However, less than a quarter of the systems offered this and therefore is another opportunity for extending current systems.

For the design of the evaluations, the review shows that most studies used a quasi-experiment design, almost two-thirds of the research only conducted a single group study, without a comparison or control group. Furthermore, roughly 70% to 80% of the evaluations had an insufficient sample size making them underpowered. Still, well-powered studies with a true experimental design are essential for studying causal effects, and therefore, for extending scientific understanding about the impact of these systems. Likewise, more long term follow-up studies, as they were rarely reported, would also help understanding lasting effects. Furthermore, despite the popularity of self-reported measures, they received criticism for their measurement bias potential [93]. Therefore, researchers should consider including other types of measures as well.

Of course, the review also has several limitations that could be noticed when considering its implications and generalisation. First, although the search included several synonyms, some authors might still have used other terms, making it impossible to claim the review to be exhaustive. Despite the possibility that the review ignored some papers, the broad search query, and the subsequently large number of systems identified makes the study's general observations likely to be reliable and representative for peer-reviewed literature in this area. Second, the review only considered systems reported in the literature, ignoring potentially commercial systems not reported in the searched literature. Third, the often reported publication towards positive results [94–96], makes that overwhelmingly positive evaluation reports should be considered with some caution. Finally, the review has only used descriptive statistics and refrained itself from apply inferential statistics. Still, the review with the papers and systems identified could form the basis for future meta-analysis.

To sum up, this review presents a comprehensive overview of the state of the art of technology-supported social skills training systems and identifies some of the characteristics, challenges, and trends in this field. Taken together, it offers inspirations for developing new social skills training systems and serve a starting point for further research.

Chapter

3

Simulating the inner voice: A study of sound parameters

This chapter is based on the article published as "Simulating the inner voice: A study of sound parameters" by Ding, D., Neerincx, M.A. and Brinkman, W.P. in Annual Review of Cybertherapy And Telemedicine 2018, p.166.

3.1 Introduction

Possibilities are, when you are reading this first sentence, you are hearing your own voice speaking in your head even if you are not saying anything out loud. This phenomenon is commonly called "inner voice", "inner speech" or referred to as "verbal stream of consciousness". Heavey and Hurlburt [97] found that in their sample, around a quarter of people's conscious waking life contains an inner voice. Much research work asserts that inner voice has a positive effect on many cognitive functions, such as self-regulation [98], self-reflection [99], and so on. Meanwhile, the stream of consciousness, already proposed by psychologist William James [100], refers to a continuous succession of thoughts in the conscious mind. It is also a narrative technique, intended to mirror people's internal psychological world and the way internal thoughts form in the mind. James Joyce's Ulysses [101] casts the thoughts and conscious experiences of characters in words in a first-person perspective, just as capturing the inner voice of characters. Based on these considerations, we propose creating virtual cognitions that work as a kind of inner voice or personalized voice-overs when people are in a virtual environment. Like virtual environment aims at replicating an environment by artificially creating sensory experiences, virtual cognitions aim at replicating thoughts by artificially creating cognitive experiences. Some replication successes have already been reported. However, these studies focus on replicating the physical body in virtual reality. For example, the rubber hand illusions or virtual body transfer illusions let people regard parts, or even their entire virtual human body as their own [102, 103]. Interesting, therefore, is to examine possible parallels for virtual cognitions to elicit an internalized mind illusion. Presenting and manipulating virtual cognitions may be a useful way to affect people's behavior and beliefs for training or therapeutic purposes.

Exposing people to virtual cognitions, presented as an inner voice, requires the simulation of such a voice and therefore understanding of the underlying sound parameters. Much research shows that there is a link between people's

inner and outer voices. On one hand, taking a developmental perspective, Vygotsky et al. [38] argue that inner voice is the result of a gradual internalization process of outer voice, while Watson [104] claims that inner voice develops with the reduction of self-directed outer voice. On the other hand, taking a functional perspective, Hickok et al. [105] propose that when people speak, an internal copy of the sound of their voice is created simultaneously with the overt sound. Scott [106] goes a step further, putting forward and testing a theory that the internal copy of people's voice can also be generated without overt sound. He also believes that the mechanism the inner voice makes use of is the one mostly applied for processing outer voice. He sees the inner voice as the results of the internal prediction of the sound of one's own voice. Moreover, Filik and Barber's findings [39] suggest that people's inner voice resembles the features of their outer voice, even their regional accent. The work presented here, therefore, explores people's perception of their simulated inner voice by considering several core sound parameters of their outer voice. Although as described above, the inner voice seems to have a close relation, even similarities, with the outer voice, Brocklehurst and Martin [40] also found that stuttering people believed their inner voice was not stuttered, which means people's inner voice might hold different sound characteristics from outer voice. We, therefore, hypothesize that people's sound parameters settings are different depending on the type of voice - inner or outer voice.

3.2 Methods

To investigate the sound characteristic of the inner voice, an empirical study was conducted. The study was approved by the human research ethics committee of Delft University of Technology (Application ID: 20).

3.2.1 Participants

15 participants (11 males, 4 females) were recruited throughout the university campus via e-mail or approached personally. Their ages ranged from

23 to 36 ($M = 26.1$, $SD = 3.52$).

3.2.2 Procedure

By using a specially developed audio recording and modification software tool, the participants first read aloud nine sentences (Appendix D) while their voice was recorded. After that, the experimenter explained the concept of an inner voice to the participants and several examples of the inner voice phenomenon (Appendix D) were given to help participants to have a clear understanding of this concept. Next, the participants had 2-3 minutes to recall their inner voice experience. After this, participants listened back to their previously recorded sentences and set key sound parameters to match their recording with their perception of either their own inner or outer voice. They modified seven basic audio effects and common digital audio-processing features [107] of the recordings: pitch, speed, echo and volume of sound with the frequency band ($20 - 320Hz$, $320 - 1280Hz$, $1280 - 5120Hz$, and $5120 - 20480Hz$). The modification data of the parameter settings was collected as input for the statistical analysis.

3.2.3 Data analysis

To analyze the participants' parameter setting data, multi-level models were used. Models were built in R version 3.4.2. All the experiment data, the R scripts, and output files can be found online[1]. Model 1 was the basic model that only included participants as a random intercept. Model 2 was built on Model 1 and added voice type as a fixed effect. Finally, Model 2 was extended by adding voice type as a random effect (Model 3). All models fitted assumed normal distribution, except models fitted on the echo settings. Here a Poisson distribution was assumed. The analysis compared the ability of the models to fit the data.

[1]These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is `10.4121/uuid:57d78b85-c9ae-4d9e-81f9-23d065913d52`.

3.3 Results

To investigate the consistency of participants' parameter settings across sentences, Cronbach's alpha was calculated for all nine sentences for each parameter, and for both inner voice and outer voice. The results show consistency for the same parameter, and for participants' settings for each sentence both inner voice and outer voice. Coefficient alpha of inner voice ranged from 0.62 to 0.93 ($M = 0.83, SD = 0.10$). Coefficient alpha of outer voice ranged from 0.69 to 0.93 ($M = 0.87, SD = 0.09$).

Table 3.1 and Table 3.2 show the results of multi-level analysis. For parameter speed, Model 3 was the most appropriate ($p < 0.01$), while for the sound volume of frequency band 1280-5120Hz, Model 2 was the most appropriate ($p < 0.05$). Except for these two parameters, Model 1 was not outperformed by the extended model for other parameters. As the results show, none of 95% confidence intervals of the standard deviation for random intercept included zero, indicating that a significant variation between participants in setting the parameters in general.

The results of multilevel analyses showed that participants set the speed, echo and the volume sound for the frequency band 1280-5120Hz differently when considering inner voice or outer voice. This suggests that people's sound parameters setting is different when it comes to the type of voice. Furthermore, the finding of a significant fixed effect indicates that the difference in volume perception for the frequency band 1280-5120Hz was consistent across participants. Here, participants set the volume higher for outer voice than inner voice. While for speed and echo the finding of a significant random effect suggests deviation across participants for setting inner and outer voices. It also suggests for speed and echo consistency on an individual level, i.e. an individual using the same speed and echo settings across his or her own nine voice recordings. For example, some participants consistently raised the speed for their inner voice and lowered it for their outer voice, while others consistently did this the other way around.

Table 3.1: Multilevel analysis results of the parameters settings for Pitch, Speed, Volume of sound with frequency band (20-320Hz, 320-1280Hz, 1280-5120Hz, and 5120-20480Hz)

Parameter	df	χ^2	p value	Lower 95%	mean	Upper 95%
P1: Pitch						
M1: Random Intercept				0.02	0.03	0.05
M2: Fixed VoiceType	1	0.30	0.59			
M3: Random VoiceType	2	4.93	0.08			
P2: Speed						
M1: Random Intercept				0.02	0.03	0.06
M2: Fixed VoiceType	1	0.97	0.33			
M3: Random VoiceType	2	11.80	0.003	0.03	0.06	0.10
P4: Volume of sound with frequency band (20-320Hz)						
M1: Random Intercept				0.10	0.14	0.21
M2: Fixed VoiceType	1	2.00	0.16			
M3: Random VoiceType	2	0.24	0.89			
P5: Volume of sound with frequency band (320-1280Hz)						
M1: Random Intercept				0.05	0.08	0.13
M2: Fixed VoiceType	1	3.01	0.08			
M3: Random VoiceType	2	1.21	0.55			
P6: Volume of sound with frequency band (1280-5120Hz)						
M1: Random Intercept				0.09	0.14	0.20
M2: Fixed VoiceType	1	7.02	0.01	0.01	0.05	0.09
M3: Random VoiceType	2	3.33	0.19			
P7: Volume of sound with frequency band (5120-20480Hz)						
M1: Random Intercept				0.11	0.16	0.23
M2: Fixed VoiceType	1	0.52	0.47			
M3: Random VoiceType	2	0.28	0.87			

Table 3.2: Multilevel analysis results of the parameter settings for Echo

Parameter			Lower 95%	mean	Upper 95%
P3: Echo					
M3: Random voice type	Fixed	Intercept	-2.99	-1.91	-0.84
	effects	voice type	-2.45	-0.97	0.51
	Random	Intercept	1.23	1.93	3.04
	Effects	voice type	1.56	2.48	3.93

3.4 Conclusion and discussion

Although the phenomenon of "inner voice" has been studied for decades, controversies concerning the nature and function of inner voice persist. In this study, we employed a parameters modification experiment to gain a better understanding of (1) the relationship between inner and outer voices; (2) the sound characteristic of the inner voice; and (3) simulated internal thoughts in virtual reality to further enable the creation of virtual cognitions. This study has some weaknesses. First, the sample size of our experiment is limited, and the participants are all university students or employees. Second, the study is an indirect perception study, asking participants to replicate the sound of their voice to the best of their abilities. It assumes that people can replicate their voice by modifying these parameters. Third, although the findings give some insight into differences between the inner and outer voices, they do not tell much about the accuracy of the replication. Future work might therefore examine this by asking people for example to rate sound recordings on an analogue scale from not very accurate to very accurate. Still, of course, such examination remains difficult because of the intensely private nature of the inner voice.

Despite these limitations, the study provides some insight into the phenomena of the inner voice needed to create virtual cognitions. Based on the results of this study, some conclusions can be drawn. First, these findings indicate that people perceive their inner voice to sound different from their outer voice. Second, individualization in the perception is observed for the dif-

ference between inner and outer voices. For developers who want to simulate inner voice in a virtual environment, these findings suggest that inner voice must be modulated separately from outer voice. The volume setting for the frequency band of 1280-5120Hz can be based on group perception, whereas for speed and echo settings it might require individualization. Interesting is also the absence of systematic differences for various bandwidths, except the 1280-5120Hz band. The 1280-5120Hz band roughly overlaps with the 1000-5000Hz band where humans have been found to be most sensitive [108], and therefore most capable to distinguish between inner and outer voices.

Recently, Craig et al. [109,110] propose using avatar therapy to let individuals talk with a computerized representation of their inner voice hallucination, aiming at reducing the frequency and severity of auditory hallucinations. It might be interesting to examine whether consistency can be found in the sound parameters settings of these recreated voices, and how they relate to people's own inner and outer voice perception. Moreover, as this study found individual differences how people perceive inner and outer voices, future work might focus on individual factors that could predict these variations as a next step in understanding how inner voice is shaped.

To conclude, this study opens up research into inner and outer voices perception and ways to simulate these voices. It has the potential of exposing people to thoughts and ideas, with applications in entertainment, education and health domains.

Chapter

4

Virtual reality negotiation training system with virtual cognitions

This chapter is based on the article published as "Virtual reality negotiation training system with virtual cognitions" by Ding, D., Burger, F., Brinkman, W.P. and Neerincx, M.A. in International Conference on Intelligent Virtual Agents, pp.119-128. Springer, Cham, 2017.

4.1 Introduction

Negotiations are very commonplace in many kinds of interpersonal relationships and being able to negotiate successfully is hence a crucial social skill. Despite this, people may choose to avoid negotiations because of a lack of skills or motivation. While many self-help books have been published on the topic, electronic solutions, so-called negotiation skills training systems, are becoming a viable alternative due to their accessibility and low cost. Existing training systems seem, however, to focus exclusively on skill development. Learners are typically taught what to do or how to behave in a negotiation situation in a learning-by-doing manner. Although feedback is provided, to the best of our knowledge, no system exists that informs learners about the reasons as to why they should behave in a certain prescribed way. The latter would be beneficial for learners as thoughtful and timely guidance is vital for the effectiveness of the learning experience [20]. Besides understanding, little attention has also been paid to people's self-efficacy, which affects their motivation to engage in negotiation. People's beliefs about their capabilities, e.g. their self-efficacy, determine how they feel, think, behave, and motivate themselves to participate in social interactions [37].

To enhance people's knowledge and self-efficacy, we put forward a virtual reality training system that allows people to passively experience a one-on-one negotiation while being exposed to a stream of thoughts of one of the virtual negotiators. These simulated thoughts, i.e. virtual cognitions, are a set of pre-recorded voice-overs that provide understandable guided learning and motivating statements. Users perceive the negotiation from a first-person perspective, hearing themselves talk and think during the negotiation.

4.2 Related work

Compared to human-human training or traditional therapy, using a computer-based system for negotiation training is more cost-effective and

controllable. There are many examples of negotiation training systems that have the potential to address the limitations of traditional negotiation training (see [111] for a game-based example and [112] for an agent-based example).

These systems aim at skill development by giving users hands-on negotiation experience. In this paper, however, we examine a training phase prior to this, focusing on building negotiation understanding and self-efficacy by using virtual cognitions.

4.2.1 Self-efficacy

Self-efficacy is one's perceived capability to execute a certain task or reach goals [113]. Multiple sources influence self-efficacy. The primary source is *enactive mastery experience*. If individuals have completed a task in the past, they are more confident in their ability to do it again in the future. Instead of obtaining such mastery experiences in the real world, individuals can also gain experiences by actively performing specific tasks in virtual environments [19, 114]. These experiences in virtual environments can affect people's self-efficacy belief in the same way that experiences in the real world do [115].

The second source of influence is a *vicarious experience* provided by social models. Observing people similar to oneself succeed raises observers' beliefs that they can master comparable activities. This effect has also been shown to hold when observing virtual agents perform in a virtual environment [116]. Also, enactive mastery and vicarious experience can be mixed in virtual reality by experiencing a virtual doppelganger from a first-person perspective [117].

Verbal persuasion in the form of encouragement and discouragement about individual's performance or capability to perform [118] is another powerful source to develop self-efficacy. Similar to the real world, when individuals receive encouragement in a virtual environment by listening to a virtual coach or hearing a conversation between virtual avatars, people's beliefs can change [119].

Wood, et al. [120] point out that positive self-statements can backfire if

they do not match the person's current belief or need. This can be explained by social judgment theory [121] as it provides a framework for the design of strong persuasive messages. Based on a person's beliefs, messages are classified into latitudes of acceptance, non-commitment, and rejection. Messages that target the latitude of non-commitment can establish the largest belief change, as messages falling into the latitude of acceptance are already close to people's beliefs, and messages falling into the latitude of rejection are likely to be rejected or even strength current beliefs. Therefore, to establish persuasive messages, a system needs to take into account a person's current self-efficacy level and the categorization of potential persuasive messages.

4.2.2 Stream of consciousness

Psychologist William James [122] coined the term stream of consciousness in 1890, to describe that thoughts can be regarded as a continuous stream and "part of a personal consciousness" (p. 225). In literature, the stream of consciousness is a narrative technique that reproduces people's internal psychological world, presenting mental observations and commentary (e.g. [101]).

Human behavior, attitudes, and cognitions are extensively influenced by people's conscious thoughts. Much research work asserts that inner voice, also known as internal monologue, plays various important roles in cognitive function, such as self-regulation [98], self-reflection [99] and, importantly, learning [123]. Helping learners to use inner voice during learning can contribute to reducing anxiety and increasing both confidence and communicative competence [124].

Based on these considerations, we propose the use of virtual cognitions to work as a kind of inner voice or personalized voice-over to present conscious thought to the user during the negotiation training.

4.3 System

Table 4.1 is an excerpt from the scripts of our negotiation dialogs and virtual cognitions that users heard when they were immersed in our VR negotiation training system. The conversations were set between the user, in the role of an employer (ER), and a virtual employee (EE), sitting across from the user. Users heard the external dialog as shown in Lines 1-3. Lines 4-6 show the virtual cognitions that users heard as part of an internal monologue. They introduce the relevant negotiation knowledge, describe the current situation, and reflect what users heard and what they should do and why. Line 5 illustrates a self-motivating statement, which users also heard during the training as one key factor of virtual cognitions. Although users played the role of the employer negotiating with an employee, they did not actively contribute to the negotiation. Instead, they heard pre-recorded audio while seeing a virtual self. For this, they wore a head mounted display. Their body movement was captured to synchronize it with their virtual body which they could see in a virtual mirror to enhance the body ownership illusion and sense of agency over the virtual body [103, 125].

The system delivered three training sessions, each addressing different negotiation topics and each set in a specific workplace scenario: (1) stages in negotiations (scenario: continuously being late for work); (2) best alternative to a negotiated agreement (scenario: requesting an immediate holiday); and (3) separate the people from the issue (scenario: quitting one's job). During the training session, users were exposed to three types of virtual cognitions (Table 4.2) as taken from the idea of social stories theory [126]: knowledge and principles, reflection, and self-motivation.

The knowledge and principles introduced in previous training sessions were reviewed to strengthen users' understanding and recollection. The reflective virtual cognitions in the first training session only focused on observations of the situation at hand. In the second and third sessions, these reflections also included thoughts about the previous negotiation. A similar strategy was

Table 4.1: Excerpt from negotiation scripts between employer (ER) Leon (the user's perspective) and virtual employee (EE) Tom.

1. EE: (Talking) Next week is the last week that it is still warm in Spain. After that it will be too cold to enjoy the beach this year. My wife likes the beach very much, and she has already been asking me to take her to a beach for over a year. Next week is the last chance for us to go.
2. ER: (Talking) Ok, I see. So you want to have a holiday immediately next week mainly because you worry that you can't take your wife to the beach later?
3. EE: (Talking) Yes, you can say that.
4. ER: (Thinking-reflection) I gathered a large amount of information about Tom's plan for a holiday and finally figured out the underlying and real reason why Tom wanted to take a vacation immediately. It was not just what he said at the very beginning about being very tried, but instead he wants to take his wife to the beach otherwise the weather could turn cold.
5. ER: (Thinking-self motivation) Leon, the negotiation is going quite well, you are doing a great job in the joint exploration stage.
6. ER: (Thinking-knowledge) Now, the negotiation will come to the next stage: bidding. The teacher emphasized that BATNA should always be kept in mind. I should share more information about my interests with Tom and develop multiple options for him to choose from.
7. ER: (Talking) Fine. I understand. How about you finish your project first, then I arrange for you to go to Egypt for a new project. You can take your wife with you, so during the weekends you can relax and enjoy the sunshine and the beach all the time.
8. EE: (Talking) Um, it sounds great, but I don't have enough money to take my wife to Egypt.

Table 4.2: Three types of virtual cognitions we used in the system.

Type	Function	Example
Knowledge and principles	Introduce the targeted knowledge and principles	"A successful negotiation usually consists of four major stages: private preparation, joint exploration, bidding, and closing."
Reflection	Describe the current situation, analyze the thoughts, feelings, and behaviors of the other parties and explain what to do and why the user should behave in the proposed manner	"Until now, Mike seems getting into a better mood. I should continue making him feel relaxed and let him know he can talk about everything he wants with me."
Self-motivation	Persuade people of their capability to perform social behaviors and encourage themselves to engage in social interactions	"Yes, great! The negotiation went well. Mike was totally calmed down. I did a great job. [User's name], you are quite good at negotiating."

followed for the self-motivation cognitions, evaluating the user's performance in current or previous negotiation, stressing feelings of mastery of experience. To target users' latitude of non-commitment towards a higher level of self-efficacy, users' self-efficacy level was measured before each training session, and matching self-reflective cognitions were selected from a validated ranked list of cognitions [127]. These self-motivation cognitions were written in the third-person perspective, which has been shown to be more effective in regulating people's thoughts, feelings and behavior compared to first-person language use [128].

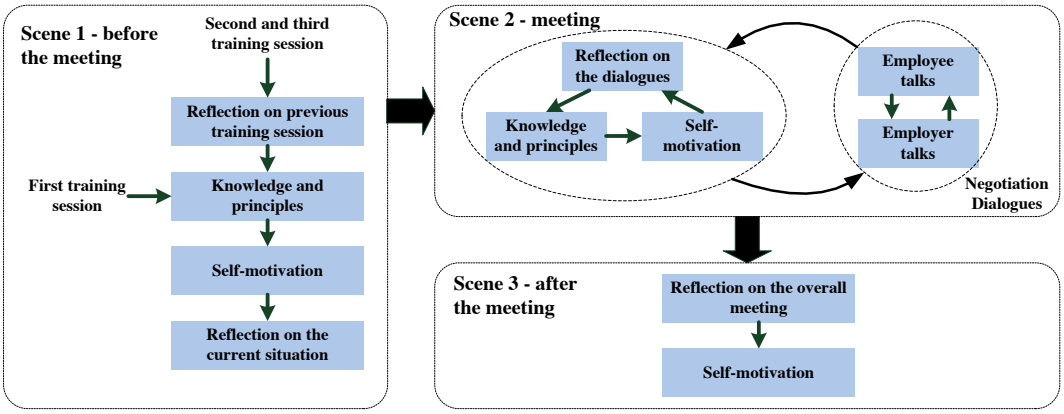

Figure 4.1: The flow of virtual cognitions and dialogues in a training session.

Each training session consisted of three scenes (Figure 4.1). The first scene was set before the meeting. Here users heard virtual cognitions reflecting on a fictional negotiation course or previous negotiations. These experiences were linked to self-motivation cognitions. The scene ends with reflections on the upcoming negotiation meeting, applying the negotiation knowledge and principle to the situation at hand. In the second scene, users started to experience the virtual negotiation in action, facing a virtual employee, which was gender-matched to the user. When the employee talked, users saw the mouth movement of the employee. When users heard their own external voice, they saw the movement of their virtual mouths in the virtual mirror. When they heard the virtual cognitions, their virtual mouth did not move. To create a natural pause in the dialog, the employee drank from his or her mug when

users were hearing an internal monologue. In the closing scene, the users were again alone in the virtual meeting room. Here they heard virtual cognitions that reviewed the process of the past negotiation, their performance and also motivated them affirmatively. The full text of all dialogues and virtual cognitions are available online[1]. An example can be found in Appendix E.1.

4.4 Method

To obtain a first evaluation of the system, we conducted a pilot study. To this end, we followed a pretest-posttest design with all participants completing the training and consequently no comparison group. The study was approved by the human research ethics committee of Delft University of Technology (Application ID: 60).

4.4.1 Participants

Eight participants (1 female) were recruited via e-mail or approached personally throughout the university campus. Their ages ranged from 22 to 29 ($M = 25.5$, $SD = 2$). Participants received a small gift in appreciation of their efforts.

4.4.2 Materials and Measures

Materials. The system captured the body movements of users with a Kinect, which returned real world distance in meters. For the HMD, an Oculus Rift DevKit 2 with a resolution of 1920*1080 pixels was used, while the virtual environment was created in Unity3D. To strengthen similarity and therefore the effect of this vicarious experience, we gave the virtual employer character the voice of the participants. We recorded all external dialogs and the virtual cognitions, resembling participant's inner voice, by asking participants to

[1]These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is `10.4121/uuid:16982115-549d-4792-973e-a7eaaff0d340`

read the sentences of the negotiation out loud prior to the training. This was done with a pair of binaural microphones (Roland CS-10EM) worn by the participant.

Self-efficacy. Following Bandura's approach [129], a one-item self-efficacy assessment was conducted. The question was formulated as: "Supposing that now you, as an employer, need to negotiate with your employee about a topic at the workplace, please rate how certain you are that you can successfully negotiate with him/her." The item was rated on an 11-point Likert scale from -5 (highly certain cannot do) to 5 (highly certain can do).

Negotiation knowledge. A validated negotiation knowledge video test [130] was used. This consists of eight negotiation scenarios (female version and male version). Each scenario includes six video scenes portraying negotiation situations. After each scene, participants are asked: "What is your advice for the employer?". Written answers are scored on the participant's ability to identify key negotiation concepts. The video test has been validated in a study with 128 participants. Mean and standard deviation for each negotiation scenario were hence available to standardize test scores.

Perceived Utility. To investigate how satisfying and useful people found the training, a 7-item utility questionnaire was used, which included three items on the satisfaction of the training process and four items on the effectiveness in improving negotiation performance. This questionnaire (Appendix F) was adapted from the one used in a study by Kang [117]. All the items were rated on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

4.4.3 Procedure

On their first visit, participants were informed of the nature of the experiment and signed their consent to participate. The pilot study consisted of three phases: pre-training, training, and post-training. In the first phase, recordings were made of each participant reading out all sentences of the three negotiation training sessions (dialogs and virtual cognitions). The order

of sentences was randomized to limit participant understanding and memorization of actual scenarios. After the recording, participants were asked to listen to one random example of their recordings and set sound parameters with the instructions to make their recordings sound as they hear their own external voice or as their inner-voice. Participants were also asked to record their names, which were later incorporated into the negotiation dialogs and self-motivation cognitions. After at least one week, we invited participants to complete an Qualtrics online questionnaire collecting demographic information and the pretest measures (self-efficacy question, negotiation knowledge test). For pre and post negotiation knowledge tests, the participants were randomly assigned to two out of the four gender matched negotiation scenarios.

Once the questionnaire was completed, participants started with the training phase. In this phase, they were invited into the lab to receive the negotiation training consisting of three consecutive sessions; each administrated on a separate day. Each training session lasted around 30 minutes, which started with five minutes of immersion into the virtual room, allowing participants to familiarize themselves with the virtual world and their virtual body before the actual scenario started. After each session, participants were asked to finish an online questionnaire to measure their self-efficacy and negotiation confidence. The latter was used to select the self-motivation cognitions in the next training session. Two weeks after entering the second phase, all participants were sent a link for the post-test measurement.

4.5 Results

4.5.1 Self-efficacy

Taking participants as a random intercept effect, two multilevel models were fitted to the self-efficacy data: a fixed intercept effect model (baseline model) and extended model that included the moment of data collection as a fixed effect. The analysis revealed a significant model fit improvement for the extended model ($\chi^2(1) = 9.65$, $p = 0.002$), suggesting that, as shown in

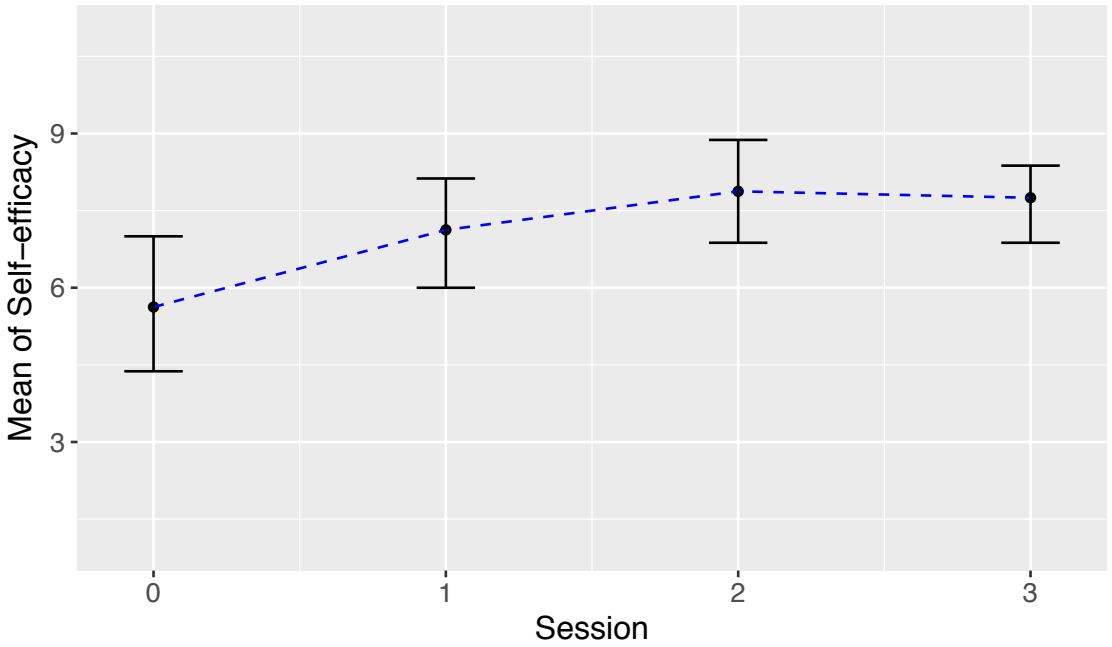

Figure 4.2: Mean (error bar 95% CI) self-efficacy score obtained before the training (0) and in the different sessions (1-3).

Figure 4.2, over time, self-efficacy increased.

4.5.2 Negotiation knowledge

Two coders scored the answers obtained from the negotiation knowledge test. With acceptable correlation ($r = 0.95$) between scores of the coders, the average score was taken, which was normalized using the scenario mean, and standard deviation available for each negotiation scenario [130]. A paired-sample t-test, revealed that participants had a significantly higher ($t(7) = 3.19$, $p = 0.015$, $d = 1.13$) negotiation knowledge score after the negotiation training ($M = 1.5$, $SD = 0.94$) than before the training ($M = 0.1$, $SD = 0.90$).

4.5.3 Perceived Utility

Cronbach's alpha was calculated for the two subscales of the utility questionnaire, satisfaction of the system ($\alpha = 0.57$) and usefulness of the system ($\alpha = 0.74$), respectively. The mean value of the items within each questionnaire was taken as a single measure of that concept. To investigate if users

hold a positive attitude about our training system, one-sample t-tests were conducted comparing scores with a value 4, the neutral position on the scale. Tests did not find significant deviations from the neutral rating, for either the satisfaction-related utility ($M = 4.17$, $SD = 0.99$) or the effectiveness-related utility ($M = 4.66$, $SD = 1.04$).

4.6 Discussion

We developed a virtual reality negotiation training system that exposes users to an unfolding negotiation, thereby witnessing both the dialog and the thought process of a negotiator. The main findings of the pilot study suggest that the training system can enhance people's negotiation knowledge and their self-efficacy, two key factors influencing a successful negotiation. The results of our pilot study thus encourage further confirmation studies with a control group to control for confounding variables or comparison with groups using other training systems or instruction delivery methods. Although the passive nature of our training might cause less anxiety to enroll, it might also make the experience less engaging and enjoyable, as the perceived utility data of the pilot study indicates. Interesting would, therefore, be to examine the effect of combining this training with existing unguided negotiation training systems where people actively negotiate with a virtual opponent.

Several design choices limit the scope of the results and should be noted to appreciate the findings. First, the format and articulation of the inner voice are very personal, as it has been found to resemble people's voice and regional accent [39]. This might have affected the pilot study as it included non-native English participants, whose everyday inner monologue might not be in English as the virtual cognitions were in the study. Similarly, the sense of agency in the virtual environment might be improved by administering vibrotactile stimulation on the thyroid cartilage when the participants hear the pre-recorded stimulus voice [131]. In our current system, users only passively experience the negotiation. Using eye-tracking in virtual reality offers the

possibility to tailor virtual cognitions to people's focus of attention in the virtual environment. It could thus provide more timely guided-learning and more thoughtful motivation. Finally, we received some negative feedback on the audio quality from the participants. The audio of the employee avatar was recorded at close range. This did not match with the spatial distance that participants had to the avatar in the virtual environment.

In conclusion, a system that provides guided learning with the combination of virtual self-experience and virtual cognitions can potentially affect people's knowledge of negotiation and self-efficacy. Further research might investigate the extent to which the system has the potential to change individual's beliefs and behavior in the long run.

Chapter

5

Simulated thoughts in virtual reality for negotiation training enhance self-efficacy and knowledge

This chapter is based on the article published as "Simulated thoughts in virtual reality for negotiation training enhance self-efficacy and knowledge" by Ding, D., Brinkman, W.P. and Neerincx, M.A. in International Journal of Human-Computer Studies, p.102400.

The work conducted in Chapter 4, which show promising results, is a pilot study for Chapter 5. Therefore, Chapter 5 conducted an extensive empirical study with larger participant number and addressing an additional hypothesis.

5.1 Introduction

Negotiation is an important aspect of daily life. Being good at it brings economic and social benefits. People improve these skills by trial-and-error or observing others negotiate. But what if they could also observe the relevant thoughts? What if they could perceive these as their own? This study examines this idea as a training strategy for knowledge and confidence building in negotiation.

Many studies point out that it is difficult for people to negotiate well [5, 6, 132]. Hence, various self-help books [5, 11, 133] have been published and courses [12] have been given. In recent years, researchers have further extended this training material with a large number of negotiation training systems. Table 5.1 gives a overview of the characteristics of some of these systems. Although these training systems are shown to be beneficial [19,53,111,134–136] thanks to their accessibility and low cost, several limitations attenuate their efficacy. First, as Table 5.1 shows, the goal of most of these systems is either to offer people opportunities to practice or to impart knowledge. While the former focuses on creating simulated negotiation scenarios, the latter focuses on teaching people what to do and how to act. However, these systems do not support people in operationalizing theoretical concepts and principles into an actual negotiation situation [20]. Often, this results in two situations. 1) The systems only increase people's knowledge, without clear performance improvement or changes in social behavior, see for example Broekens et al. [19]. 2) When users already have basic knowledge or negotiation experience, only giving them a chance to experience a negotiation or teach them negotiation principles is unlikely to result in clear skill improvement. Kim et al. [48], for example, found that for individuals without prior negotiation experience, their situational judgment test score was improved significantly after the training, while for those with prior negotiation experience, the training failed to bring out a significant improvement. Moreover, people, particularly novices, have trouble with applying their newly gained knowledge, despite being able to

remember everything taught in the training [137].

Second, training of skills gets the most attention as shown in Table 5.1. Training systems often neglect the importance of the individual's own confidence, motivation and willingness to participate in a negotiation. This, however, is essential to initiate the negotiation. People's beliefs about their capabilities, i.e. their self-efficacy not only affect their negotiation behavior and performance [138], but also influence their performance after negotiation training [139, 140]. Fortunately, there are strategies to improve people's self-efficacy, thus increasing their motivation and willingness to engage in activities [22]. For instance, according to social cognitive theory [23], people's self-efficacy can be affected in four ways: mastery experience, vicarious experience, verbal persuasion, and their emotional and physiological states. If they are not used in an appropriate way, though, self-efficacy can also suffer. In fact, using a training system can lead both to mastery of a skill and the experience of failure. Such experiences of failure can lead to the decrease of one' s self-efficacy, especially when a sense of efficacy has not yet been firmly established [141]. A solution to this is the addition of guidance in the form of appropriate instructions, explanations, or reflection. Guidance can be provided in a third-person or first-person perspective, the latter being shown to be more effective. For example, students have been found to learn better from instructional videos recorded from a first-person perspective than a third-person perspective [142]. Our vision is to create a system that addresses the earlier mentioned limitations by focusing on people's negotiation understanding and self-efficacy. This is done by letting people experience negotiation, both visual and cognitively from a first person perspective. The cognitive experience is realised in the form of virtual cognitions, i.e. a stream of thoughts, simulating the thinking process during a negotiation. Virtual cognitions consist of guided learning and motivating statements. We believe that virtual experience with virtual cognitions can enhance people's negotiation knowledge, but perhaps more importantly, can also increase their self-efficacy.

Table 5.1: Negotiation training system reported in the literature

Author	Intervention goal					Measurement			
	Learn by doing	Imparting knowledge	Motivation	Reflection	Feedback	Performance	Satisfaction	Self-efficacy	Knowledge
Greco et al. (2007)	✓				✓	✓	✓		
Lin et al. (2009)	✓					✓			
Ross Jr et al. (2001)	✓	✓				✓	✓		✓
Broekens et al. (2012)	✓				✓*	✓			✓
Gratch et al. (2015)	✓					✓	✓		
Gratch et al. (2016)	✓				✓	✓	✓		
Kim et al. (2009)	✓	✓		✓	✓	✓	✓		✓

Note, *only providing emotions as feedback

5.2 Background theory and hypotheses

Social skill training systems aim at overcoming shortcomings of face-to-face training such as the high costs and the lack of controlled social interaction [54]. With the advent of virtual reality technology, social skills training systems using this technology have been developed. These systems can provide an enriched, ecologically valid, interactive and enjoyable training environment [143]. Several studies demonstrate their effectiveness. For example, these systems can reduce people's public speaking anxiety [17, 144, 145], teach communication skills to pediatric residents [146], and improve individual's job interview skills [147, 148]. More specifically for negotiation, they could boost individual's negotiation skills [19].

As discussed above, one important element that a training system should offer is guidance and mentoring. Providing reflection, feedback and explanations affects the efficacy of the system [48]. Taking it one step further, these systems should aim at improving people's self-efficacy in negotiation. This determines how people feel, think, behave and motivate themselves to engage in social interactions [141]. Self-efficacy can be altered in four ways as stated previously and this can also be achieved in virtual reality environments [115, 149]. For instance, individuals can gain mastery experience by actively performing specific tasks in virtual environments [114, 150] or vicarious experience by observing virtual agents perform a task [116, 119].

Furthermore, as the vision puts forward, these ways of influencing might also be established with an artificial stream of thoughts combined with simulated speech. Offering these thoughts from a first-person perspective as a simulated inner voice could reproduce people's internal psychological world, present people with mental observations and commentary. Inner voice, also known as an internal monologue, is believed to play a role in various cognitive functions, such as self-regulation [38], self-reflection [99] and, importantly, learning [123]. Guiding users to use inner voice during learning can, for example, reduce anxiety and increase both communicative competence and

confidence [124]. Receiving guidance through simulated inner voice, therefore, has the potential to enhance mastery or vicarious experience. The impact of the vicarious experience depends on how much people can identify with the observed person [141]. For instance, children with autism master more novel letters and even learn more quickly when watching videos of themselves compared with watching videos of someone else [151]. This suggests a larger impact if people are exposed to inner voice and simulated speech with sound characteristics similar to their own. If a person would perceive the virtual thoughts and speech as their own, it might also trigger attitudinal change. After all, the cognitive dissonance theory [152] postulates that people with conflicting cognitions and behaviours tend to resolve this by realigning them.

Additionally, verbal persuasion and changes in emotional and physiological states can also be achieved with positive self-motivational statements. For example, reading aloud positive self-statements or self-instructions had a positive effect on people's self-esteem and decreased feelings of inadequacy [41] and even depression [42]. Therefore, one new intervention method to increase self-efficacy is using virtual cognitions as a kind of inner voice or personalised voice-over. It presents conscious thoughts to the user combined with simulated speech during the negotiation training. These virtual cognitions can play the role of (1) guidance and instructions to enhance mastery and vicarious experience or (2) self-motivational statements to verbally persuade and change emotional and physiological states. It allows users to passively experience how a successful negotiation process unfolds from a first-person perspective. Hence, it opens the possibilities to enhance people's self-efficacy, leading to following hypotheses:

H1: Passive virtual reality negotiation training with virtual cognitions and simulated speech improves negotiation knowledge and self-efficacy of negotiation compared to no training.

H2: Virtual cognitions with self-motivational statements improve self-efficacy more than virtual cognitions without self-motivational statements.

5.3 Research approach

Testing these hypotheses involved several activities that ultimately led to a randomised controlled experiment. First of all, the idea discussed above was translated into a fully functional training system. For testing the first hypothesis, this meant that the system was able to provide users with the experience of negotiating from a first-person perspective complete with virtual cognitions and simulated speech. The second hypothesis, about the effect of self-motivational statements, required the creation of a set of these statements. They varied on the expressed self-efficacy in negotiation. The set allowed the system to select a statement appropriate to the individual's level of self-efficacy, and to measure people's negotiation attitude. Also, the training which was developed consisted of scripts for three consecutive training scenarios. Besides creating the content, dedicated software for recording the virtual cognition text was developed, including software that allows individuals to set sound parameters to match their own recorded voice with that of their inner or outer voice perception [153].

The first hypothesis is about negotiation knowledge enhancement. It requires a reliable and validated negotiation knowledge measure. For this, a series of negotiation videos was developed following the strategy also used by Broekens et al. [19]. People's reflections on these videos gave insight into their negotiation knowledge [154]. This measuring instrument, together with the developed training system, was eventually applied in the experiment. The following chapters provide a detailed account all of these activities.

5.4 System, content and training

The training system was developed using immersive virtual reality technology. To examine hypothesis one, we developed a training system with virtual cognitions combined with simulated speech. An initial pilot study [155] showed promising results for enhancing knowledge and self-efficacy, however, it was

only a single-group study with a quite small sample size. As for hypothesis two, the system provided two types of training, training with and without self-motivational cognitions. The system provided a series of negotiation scenarios in a virtual meeting room.

5.4.1 General idea

To give a brief idea of the training content, table 5.2 shows an excerpt from the negotiation script translated into English. The scripts incorporate the negotiation dialogues and the virtual cognitions that users heard when they were immersed in the virtual reality (VR) negotiation training system. The negotiation occurs between the user, playing the role of an employer, and a virtual employee who sat across the user. To avoid gender effects, the gender of the employee and the employer was matched with that of the user. During the training, users heard both the external dialogue (lines 1-7) and the virtual cognitions as part of an internal monologue (lines 8-10). Line 8 show the virtual cognitions that describe the current situation, reflect on what users heard, what they should do, and why. Line 9 illustrates a self-motivational statement, heard as one key component of virtual cognitions. The virtual cognitions in line 10 introduce the relevant negotiation knowledge.

The negotiation skills training system is a 3D immersive virtual reality system. In the system, users can explore a virtual self-experience in a negotiation context. They play the role of an employer, passively experience negotiating with a virtual employee, sitting opposite them. It is a passive experience as they do not actively negotiate. Instead, they perceive the negotiation from a first-person perspective, seeing and hearing their virtual-self talk with the virtual employee. Furthermore, they hear their virtual-self thinking by hearing pre-recorded audio. For this, they wore a head mounted display and a pair of microphones (Figure 5.1). For any system that provides human-computer interaction, the sense of agency could be vital considering that it affects how people experience interactions with technology [156]. In our system, users' body movement was captured to synchronize it with their virtual body which

Table 5.2: Excerpt from negotiation scripts between the employer (ER) John (the user's perspective) and virtual employee (EE) Mike.

1. ER (Thinking-reflection) I have already known Mike for a long time, he has a good reputation in the company, but according to the teacher's advice, I need to separate the people from the problem. Be soft on him, hard on the issues we faced. Of course, when he felt down, I should console him in a friendly way. However, when it comes to the rules, I still should consider the problem in a matter-of-fact way, not making concessions because of the relationship between us or to cultivate the relationship. It is better to explore the current situation more.
2. ER (Talking) Mike, let's try to solve the problem together. Have you already got any offer from another company?
3. EE (Talking) No, I haven't. I don't have time to find a job. I am still stuck in the work at hand and my wife recently broke her legs in an accident.
4. ER (Talking) What? Did she break her legs? Is she ok? What happened?
5. EE (Talking) She fell from her bike when she was hit by a motorcycle at a street corner. The accident was quite serious, she was kind of lucky that she just broke her legs.
6. ER (Talking) I am really sorry to hear that. I believe it could be quite difficult for you. Would you mind telling me a little bit more?
7. EE (Talking) It happened last month, the doctor said she had to stay in bed, at least for two months. I must take care of her every day. Taking care of both my family and the job at the same time is very exhausting. My feeling tells me I should leave the team and make some changes in my life.
8. ER (Thinking-reflection) I gathered a large amount of information about Mike's working and living condition. I explored a lot about his desires and the underlying reason why Mike wants to leave his job now. Now, the reasons why he wanted to leave his job seem clear.
9. ER (Thinking-self motivation) John, the negotiation is going quite well, you are doing a great job in the joint exploration stage.
10. ER (Thinking-knowledge) Now, the negotiation will come to the next stage: bidding. The most essential thing in this stage is to develop multiple options for Mike to choose from.
11. ER (Talking) Mike, how would you feel about finishing your work first and I arrange for you to transfer to another team?
12. EE (Talking) Moving to another team? Eee...That sounds ok, but I have to say I am a little bit worried that all the troubles I experienced in the current team will come out again.

they could see in a virtual mirror to enhance the body ownership illusion and sense of agency over the virtual body [103, 125].

Figure 5.1: Experiment setting (top) and screen shot (bottom) of the training scenario from the perspective of users where they see their virtual representation in the mirror and the virtual employee in front of them.

The system delivered three training sessions, with each session addressing a negotiation principle: (1) the main stages of negotiation, (2) best alternative to a negotiated agreement (BATNA), and (3) separate the people from the issue [5]. Each session was set within its own negotiation scenario, triggered by a work-related event: (1) continuously being late for work; (2) requesting an immediate holiday; and (3) announcing resignation. During the sessions, users were exposed to three types of virtual cognitions (Table

5.3): knowledge and principles of negotiation, reflection on the negotiation process, and self-motivational statements. The second and third session also used knowledge and principles addressed in previous sessions, strengthening the users' understanding and recollection. The reflection element also built on experiences in past sessions. Whereas in the first training session, the reflective cognitions only focused on the current situation in progress, in the second and third sessions, they related back to thoughts and experience obtained in the previous negotiations.

5.4.2 Content generation of self-motivational cognitions

Self-motivational cognitions were adapted to users' states, giving positive feedback on the user's performance in current or previous negotiation, stressing feelings of mastery of experience. A potential risk, however, was that people would ignore the virtual cognitions as a strategy to resolve their cognitive dissonance with their actual beliefs. Following social judgment theory [121], these cognitions could be classified into latitudes of acceptance, non-commitment, and rejection. Cognitions that target the latitude of non-commitment might be able to establish the largest belief change, as cognitions that fall into the latitude of acceptance are already close to people's beliefs. Less likely to be accepted are cognitions that fall into the latitude of rejection, as they are probably rejected or even cause negative effects. In other words, depending on their current self-efficacy belief, people should hear different self-motivational statements, ranging from 'I am an average negotiator.' to 'I have never failed in a negotiation.'.

To create the content of the training delivered by the training system, an ordered list of self-motivational statements that formed the self-motivational virtual cognitions had to be established. For this, we followed the strategy of creating a Thurstone scale using the method of equal-appearing intervals [157]. It was conducted as a separate study before our main experiment which is described in the next section. The first step was a brainstorm session to create candidate statements that describe specific attitudes people might

Table 5.3: Three types of virtual cognitions used in the system.

Type	Function	Example
Knowledge and principles	Introduce the targeted knowledge and principles.	"The teacher also taught me one essential strategy that can be applied during the negotiation. What's that? ...hmmm...Yeah, I see. 'Separate the people from the problems'. I should be soft on the people, but hard on the problems."
Reflection on the process	Describe the current situation, analyse the possible thoughts, feelings, and behaviours of the other parties and explain what to do and why to behave in a certain manner.	"It seems Mike was crushed by the work, I ought to console him a little bit. However, when it comes to the issues that he wanted to leave the job immediately, I still have to let him know it's not possible as there is clear notice period for resigning in his contract. Soft on people, hard on the problem. I should keep that in mind and follow it."
Self-motivational statements	Persuade people of their capability to perform social behaviours and encourage themselves to engage in social interactions	"Yeah, we are almost there. I developed lots of options for Mike to choose from and successfully applied the BATNA in a smart way, so I finally figured out a proposal which satisfies the interests of both parties. [User's name], you did a great job in the joint bidding stage. You are a quite good negotiator."

hold towards negotiation revealing their self-efficacy about negotiation. This resulted in a list of 136 statements that were relatively short, colloquial language and containing only one single thought. Afterwards, these statements were given to a panel of 21 judges. They rated each statement on a scale from 1 (no self-efficacy) to 11 (very high self-efficacy). Finally, the mean score and the standard deviation (SD) of each statement was calculated. A cut-off point for including a statement in the final list was empirically determined and set as $SD = 1.42$. Thereby, on one hand, it balances the aim of maximising the number of scale levels and the level of agreement between the judges, and on the other hand, it settles on a sufficient large number of statements in the consecutive interval to create one equivalent Thurstone scale and to fill three negotiation sessions. This resulted in a set of 116 statements, grouped in seven consecutive intervals [158]. The statement with the lowest SD in each interval was chosen to represent the group of statements in this interval. Together these seven statements constitute the negotiation attitude scale (Appendix G) following the idea of the Ordered Alternatives Questionnaire [159].

Before each training session, users first completed the negotiation attitude scale. They were asked to sort each item into one of five categories: most objectionable, objectionable, neither accepted nor objectionable, acceptable, and most acceptable. The items that users find acceptable constitute their latitude of acceptance, the items that users indicate to be objectionable to them form their latitude of rejection, and the items that users neither accept nor reject refer to the latitude of non-commitment. The item with highest negotiation attitude scale score that was labeled as non-commitment was chosen. The statements from the interval of this chosen item were then the self-motivational statements the users heard in the subsequent training. However, if all items of non-commitment were below “4” (the middle of the scale), the items of interval “4” were selected.

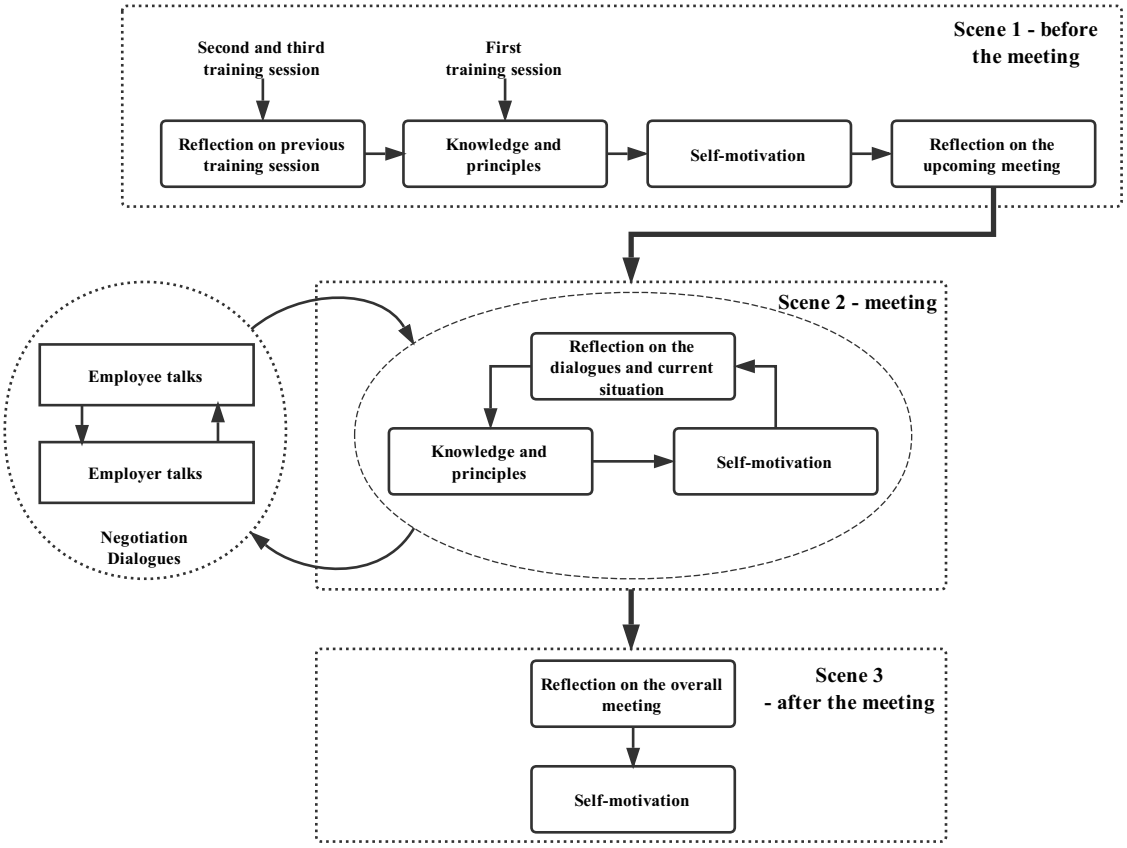

Figure 5.2: The flow of virtual cognitions and dialogues in training sessions.

5.4.3 Training

When it came to the training sessions, each consisted of three scenes (Figure 5.2). The first scene corresponds to the preparation stage of negotiation. During this period, users were sitting alone in the virtual meeting room, hearing virtual cognitions recalling the knowledge learned from a fictional negotiation course or reflecting on the previous negotiations. The reflection was accompanied by self-motivational statements. The scene ended in reflections on the upcoming meeting with the employee, pre-applying the negotiation knowledge and principles to the possible impending situation. The second scene was the formal start of negotiation between users and a gender-matched virtual employee. Users experienced the virtual negotiation in action. To enhance the illusion of being there, users could see the movement of their

virtual mouths in the virtual mirror whenever they heard their own external voice. When they heard the virtual cognitions, their virtual mouth did not move. Of course, when the employee talked, users also saw the employee's mouth move. Moreover, to create a natural pause in dialogues, the virtual employee drank from his or her virtual mug when users were hearing a virtual cognition. In the closing scene, the users were again alone in the virtual meeting room like in the first scene. They heard virtual cognitions that reviewed the process of the past negotiation, their performance, and also motivated them affirmatively. The full text of all dialogues and virtual cognitions, both in English and Mandarin, are available online[1]. An example can be found in Appendix E.2.

5.5 Method

The study was designed with pre-training, post-training, and 2-week follow-up measures, as shown in Figure 5.3. The study was approved by the human research ethics committee of Delft University of Technology (Application ID: 60).

5.5.1 Participants

48 participants (31 males, 17 females) were recruited from the university campus via e-mail or approached personally. Their ages ranged from 23 to 32 ($M = 26.8$, $SD = 2.04$), and all spoke fluently Mandarin. They also all understood English well as they had to meet the university's English language proficiency requirement.

[1]These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is `10.4121/uuid:225bf41f-d399-4341-adfb-07aaafa6a39b`

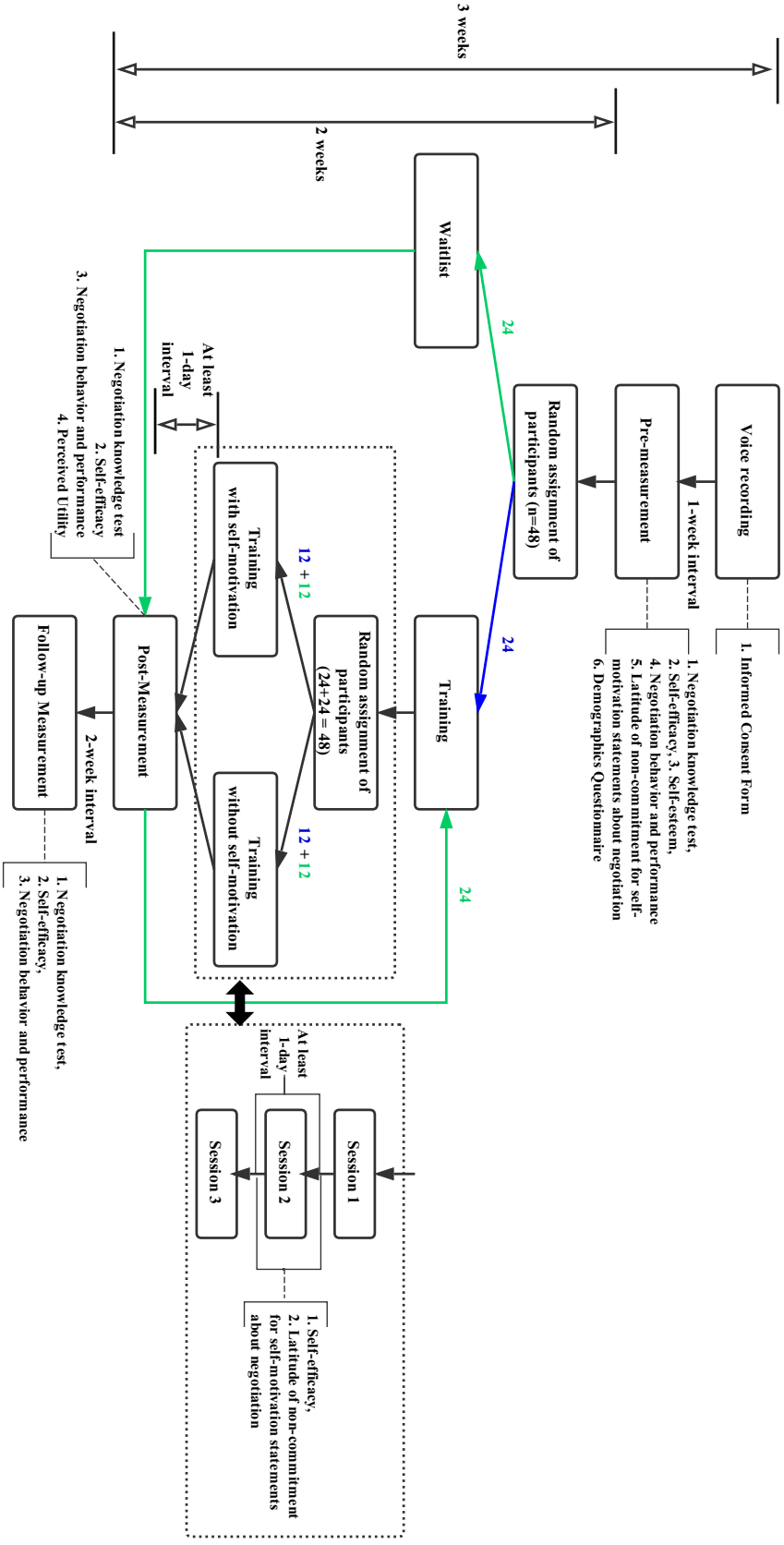

Figure 5.3: Experiment procedure and measures obtained in the corresponding phases.

5.5.2 Materials and measures

The system captured the body movements of users with a Kinect, which returned real-world distance in meters. For the head-mounted display, we used the Oculus Rift DevKit 2 with a resolution of 1920*1080 pixels, while the virtual environment was created in Unity3D. To strengthen similarity and therefore the effect of this vicarious experience, we gave the virtual employer character the voice of the participants. All dialogues and virtual cognitions were in Mandarin. In the recording phase, they were presented to participants in a random sequence. Participants read them out loud and were recorded with a pair of In-Ear Binaural microphones (SP-TFB-2 Sound Professionals). In the later training sessions, these recordings were played back to them. The training content were delivered in Mandarin in order to match the users' mother tongue, while the questionnaires used in pre, post, and follow-up tests were in English.

5.5.2.1 Primary outcome measurements

Self-efficacy. Following Bandura's approach [129], a one-item self-efficacy assessment was conducted. The question was formulated as: "Supposing that you now, as an employer, need to negotiate with your employee about a topic at the workplace, please rate how certain you are that you can successfully negotiate with him/her." The item was rated on an scale from -5 (highly certain cannot do) to 5 (highly certain can do).

Negotiation knowledge. The negotiation knowledge here refers to the three negotiation principles we addressed during the three training sessions. The negotiation knowledge video test was used to measure the participants' mastery of these principles. The test consisted of eight negotiation scenarios (female version and male version) each including six video scenes portraying negotiation situations. After each scene, participants were asked: "What is your advice for the employer?". Written answers were afterwards scored on the participant's ability to identify key negotiation knowledge or principles. To gender match the video material, both a female and male version was

created by using all female or male cartoon characters in the videos.

The video test was validated in a separate study with 128 participants (66 females, 62 males). These participants were recruited using Amazon Mechanical Turk, only the participants with HIT Approval Rate greater than 95% were allowed to attend this experiment, which ensures high-quality data as suggested by Peer et al. [160]. Their ages ranged from 19 to 71 ($M = 37.9$, $SD = 12.16$). The study was set up as a between-subject experiment that includes two groups: the informed group and non-informed group. In the informed group, the participants were first instructed to watch a training video, which explained the negotiation principles needed for the following test (Appendix H). As a requirement for participation, participants had to answer several questions on negotiation correctly. Then, the remaining participants were assigned to watch the test videos and after watching each video, they were asked to enter their advice for the employer in the video. During this period, the participants in the informed group were allowed to view a description of the principles mentioned in the training video, ensuring that participants in the informed group mastered the knowledge continuously. The non-informed group took the negotiation knowledge test immediately without any training session or access to the description of negotiation principles. The experiment took about 30 minutes. Participants were awarded 2 US dollars. Afterwards, a coder scored the participants' answers on the successful application of the negotiation principles. An acceptable level of agreement ($r = 0.92$) was found with the rating of a second coder on a randomly selected sample ($n = 24$) from the participants' answers. Comparing the group scores confirmed a significant difference ($t(70.97) = 5.48$, $p < 0.001$, $d = 1.11$) between the informed group ($M = 41.31$, $SD = 15.81$) and the non-informed group ($M = 27.31$, $SD = 10.24$) validating that the test could measure differences in the ability to apply the negotiation knowledge. Mean and standard deviation for each negotiation scenario was hence available to standardize test scores.

5.5.2.2 Secondary outcome measurements

5.5.2.2.1 Negotiation behaviour and performance

Negotiation satisfaction. To measure the participants' satisfaction with the negotiations they experienced pre-post-follow-up the training, a 4-item questionnaire was used, which measures the satisfaction covering four aspects [161]: the negotiation process, their own performance, the relationship with counterpart(s) of the negotiation, and the negotiation outcome. All the items were rated on a 11-point scale from -5 (extremely dissatisfied) to 5 (extremely satisfied).

Negotiation frequency. To examine the negotiation frequency pre-post-follow-up the training, a questionnaire was created that followed a similar design as the quantitative physical activity recall questionnaire [162]. It asked how often people negotiated over a two-week period in different situations, such as buying or selling an item, negotiating a date for a meeting, negotiating the division of work, and so on.

Negotiation results. Participants were asked to self-report their negotiation results in their daily life. The questions were formulated as: "What percentage of negotiations end with a satisfying outcome for you?" and "What percentage of these negotiations were win-win negotiations (both parties benefited)?".

5.5.2.2.2 Perceived utility

To investigate how satisfying and useful people found the training, a 7-item utility questionnaire was used. It included three items on the satisfaction of the training process and four items on the effectiveness in improving negotiation performance. This questionnaire (Appendix F) was adapted from the one used in a study by Kang [149]. All the items were rated on a 7-point scale from 1 (strongly disagree) to 7 (strongly agree).

5.5.2.2.3 Co-variation measurements

Self-esteem. Self-esteem was measured using the Rosenberg self-esteem scale [163], a ten-item scale assessing the degree of one's perceived self-esteem.

All items were answered on a 4-point scale ranging from 0 (strongly disagree) to 3 (strongly agree).

5.5.3 Procedure

This study consisted of four phases: pre-training, training, post-training and follow-up. In the first phase, participants were informed about the nature of the experiment and signed the consent form. After this, recordings were made of each participant reading out all sentences of the three negotiation training sessions including the dialogues and virtual cognitions. These also included all the self-motivational cognitions. The order of sentences was randomized to limit participants' understanding and memorization of actual training content. Next, to cater for reported variation between individuals' outer and inner voice perception [153], participants were asked to listen to one random example of their recordings and instructed to set sound parameters to make the recordings sound as they hear their own outer voice or as their inner voice. Participants were also asked to record their names, which were later incorporated into the negotiation dialogues and self-motivational cognitions. After at least one week, participants were invited to complete an online questionnaire collecting demographic information and the pre-test measures (self-efficacy question, negotiation performance and behaviour questions, self-esteem, and negotiation knowledge test). For pre, post, and follow-up negotiation knowledge tests, each participants were randomly assigned to three out of the four gender matched negotiation scenarios.

Once the questionnaire was completed, the participants started the two-week training phase. In this phase, they were randomly assigned to one of three groups: a waitlist group, a direct training without self-motivational statements group, and a direct training with self-motivational statements group. The participants who joined the latter two groups were given the virtual reality negotiation training consisting of three consecutive sessions, each administrated on separate days. Each training session lasted around 30 minutes, starting with completing the negotiation attitude scale, followed

by three minutes of immersion into the virtual environment, allowing participants to familiarize themselves with the virtual world and their virtual body before the actual training started. Before each session participants were instructed to be open-minded towards virtual cognitions as self-affirmation has been reported to lead to more attitude change [164]. The instruction was "Before the training starts, please also remember to be open-minded in the upcoming training when considering the idea put forward and the dialogues with the employee." After each session, participants were asked to finish an online questionnaire to measure their self-efficacy and negotiation confidence. Meanwhile, the participants in waitlist group were initially not given any negotiation training. Two weeks after entering the second phase, all participants were asked to fill in all online questionnaires again and finish the negotiation knowledge test. In order to increase the sample size, the participants in the waitlist group were also given the opportunity to experience the training, they were afterwards randomly assigned to the two training groups and experienced the training protocol as described earlier.

The fourth phase was conducted two weeks after the post-measurement. In this phase, participants were asked to again complete the online questionnaires for self-efficacy, negotiation performance and behaviour as well as the negotiation knowledge test.

5.5.4 Data preparation and analysis

5.5.4.1 Data preparation

Reliability analysis of the self-report questionnaire. We randomly assigned the 48 participants to the training condition ($n = 24$) or a waitlist condition ($n = 24$), training with self-motivation condition ($n = 24$) or training without self-motivation condition ($n = 24$). Table 5.4 and 5.5 show demographic information and pre-measurement data of the participants, as well as the randomization check. At baseline, the groups did not differ significantly on any demographic characteristics and pre-measurements (all P values $> .05$)

Reliability analysis of the coding of the negotiation knowledge test After a single coder blindly scored all answers from the negotiation knowledge test, a second coder also blindly scored a sample of the answers. Using the $n = 1/E^2$ rule [165], a random sample of 28 was considered adequate to examine inter-rater reliability with an error margin of .95 as observed in the pilot study ($pa = 0.95$) [155]. Comparing the scores of the two coders revealed an acceptable reliability level of (Krippendorff's $alpha = 0.94$).

Reliability analysis of the utility questionnaire Cronbach's alpha showed acceptable levels of reliability for the two subscales of the utility questionnaire, the satisfaction of the system ($\alpha = 0.68$) and usefulness of the system ($\alpha = 0.83$), respectively. Hence, the mean value of the items was used in subsequent analyses.

Covariation check As Wood et al. [120] reported that people with high self-esteem will benefit more from self-motivational statements compared to people with low self-esteem, self-esteem was examined as a potential covariation. Likewise gender was also examined as a potential covariation. As no correlation with any of the dependent variables was found, analyses with covariates were not deemed justified.

5.5.4.2 Analysis

To examine the effects of our training system and the sustainability of the effects, t-tests were conducted on the primary outcome measures, Wilcoxon Signed-Rank test (for one sample) and Wilcoxon Mann–Whitney test (for two samples) were conducted on the secondary outcome measures. They included paired comparisons of pre-post and pre-followed-up measurements. Furthermore, they included between-group comparisons on the differences observed in pre-post and pre-follow-up measurements. We also calculated the effect sizes d and r, whereby a Cohen's d of 0.20 indicated a small effect, 0.50 a moderate effect, and 0.8 a large effect [166]. For effect size expressed with r, classification was: 0.10 for small effect size, 0.30 for a medium effect size, and 0.50 for a large effect size [166].

Table 5.4: Demographic characteristics and pre-measurements of waitlist vs training groups

		Waitlist vs Training			
		Waitlist (n=24)	Training (n=24)	Statistic	P value
Age		26.6 (1.93)	27.0 (2.18)	$t_{46} = -0.56$	0.58
Gender	Female	7	10	$\chi^2_1 = 0.82$	0.37
	Male	17	14		
VR Experience	Yes	9	12	$\chi^2_2 = 0.82$	0.66
	No	13	10		
	Maybe	2	2		
Self-efficacy		2.21 (1.61)	1.83 (2.30)	$t_{46} = 0.65$	0.52
Negotiation knowledge		22.17 (12.29)	23.50 (11.62)	$t_{46} = 0.39$	0.70
Negotiation frequency		6.67 (11.84)	7.50 (8.23)	$Z = 1.25$	0.22
Negotiation satisfaction		2.14 (1.30)	1.75 (1.57)	$Z = -0.73$	0.47
Negotiation results		0.75 (0.23)	0.71 (0.25)	$Z = -0.66$	0.51

Table 5.5: Demographic characteristics and pre-measurements of training with vs without self-motivation groups

		Training with self-motivation vs Training without self-motivation			
		with self-motivation (n=24)	without self-motivation (n=24)	Statistic	P value
Age		27.2 (1.56)	26.4 (2.39)	$t_{40} = 1.43$	0.16
Gender	Female	8	9	$\chi^2_1 = 0.09$	0.76
	Male	16	15		
VR Experience	Yes	12	9	$\chi^2_2 = 0.82$	0.66
	No	10	13		
	Maybe	2	2		
Self-efficacy		1.29 (2.03)	2.00 (1.69)	$t_{46} = 1.31$	0.20
Negotiation knowledge		22.88 (10.45)	22.04 (12.01)	$t_{46} = 0.26$	0.80
Negotiation frequency		6.62 (8.27)	5.04 (3.14)	$Z = 0.12$	0.91
Negotiation satisfaction		1.51 (1.60)	1.96 (1.24)	$Z = 1.09$	0.28
Negotiation results		0.64 (0.28)	0.76 (0.22)	$Z = 1.39$	0.17

Multi-level analyses examined the effects of the three training sessions on self-efficacy measured directly after each session. The analysis included four multi-level models. Model 1 was the basic model that only included participants as a random intercept. Model 2 added the fixed factor training sessions to model 1. Model 3 was built on Model 2 and added group as a fixed effect. Finally, Model 3 was extended by adding the interaction effect between group and training sessions (Model 4).

One-sample t-tests examined participants' attitude towards the training system, by comparing the scores on perceived utility scale with a value 4, the neutral position on the scale. Furthermore, a t-test examined the effect of two training conditions on the scores of this scale.

All analyses were carried out with R version 3.4.2. All the experiment data, the R scripts, and output files can be found online[1].

5.6 Results

5.6.1 Pre, post, and follow-up

As shown in Table 5.6, no significant difference between pre and post measurements were found for the waitlist group for any of the outcome measures. However, for the training group, significant improvements between pre and post measurements were found for self-efficacy, negotiation knowledge, negotiation results, but not for negotiation satisfaction and negotiation frequency. These difference between waitlist and training group was were also confirmed by significant differences found between these two groups and differences observed between pre and post training improvement for self-efficacy, negotiation knowledge, and self-reported negotiation satisfaction and results. Differences were also found between the two training groups for the degree in pre and post improvement. Moreover, as Table 5.7 shows, compared to

[1]These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is `10.4121/uuid:f41957e5-8532-40ee-9ddd-24186118813f`.

Table 5.6: Primary and secondary outcome measures comparison between pre and post measurement for the waitlist and training condition, and comparison between pre and post differences between the groups.

	Waitlist			Training			Waitlist vs Training		
	t	p	d	t	p	d	t	p	d
Self-efficacy	-1.73	0.09	0.43	2.04	0.048	0.71	3.92	< 0.001	1.13
Negotiation knowledge	-0.22	0.82	0.07	3.87	< 0.001	0.95	4.16*	< 0.001	1.20
	z	p	r	z	p	r	z	p	r
Negotiation Frequency	-0.39	0.69	0.06	-0.61	0.54	0.09	1.12	0.27	0.16
Negotiation Satisfaction	-1.35	0.18	0.19	-1.74	0.08	0.25	2.18	0.03	0.31
Negotiation Results	-0.79	0.43	0.11	-2.34	0.02	0.34	2.02	0.04	0.29

Note, $df = 46$ for t-tests, with the exception of * for 39.

Table 5.7: Primary and secondary outcome measures comparison between pre and post measurement for the training without and with self-motivation condition, and comparison between pre and post differences between the groups.

	Training without self-motivation			Training with self-motivation			Training without self-motivation vs Training with self-motivation		
	t	p	d	t	p	d	t	p	d
Self-efficacy	0.83	0.41	0.43	3.40	< 0.01	1.26	4.10*	< 0.001	1.18
Negotiation knowledge	2.80	< 0.01	0.76	4.02	< 0.001	0.95	0.21	0.83	0.06
	z	p	r	z	p	r	z	p	r
Negotiation Frequency	-1.77	0.08	0.26	-1.18	0.24	0.17	1.65	0.10	0.24
Negotiation Satisfaction	-0.52	0.60	0.08	-2.79	< 0.01	0.40	-2.66	< 0.01	0.38
Negotiation Results	-0.13	0.90	0.02	-2.94	< 0.01	0.42	-2.67	< 0.01	0.39

Note, $df = 46$ for t-tests, with the exception of * for 39.

Table 5.8: Primary and secondary outcome measures comparison between pre and follow-up measurement for the training without self-motivation and training with self-motivation condition, and comparison between pre and follow-up differences between the groups.

	Training without self-motivation			Training with self-motivation			Training without self-motivation vs Training with self-motivation		
	t	p	d	t	p	d	t	p	d
Self-efficacy	0.66	0.51	0.26	2.28*	0.03	0.75	2.18	0.03	0.64
Negotiation knowledge	2.69	0.01	1.01	2.22*	0.03	0.52	-0.71	0.48	0.21
	z	p	r	z	p	r	z	p	r
Negotiation frequency	-0.40	0.69	0.06	-1.27	0.20	0.18	1.47	0.14	0.21
Negotiation satisfaction	-0.67	0.51	0.10	-2.01	0.04	0.29	-2.07	0.04	0.30
Negotiation results	-0.34	0.74	0.05	-2.32	0.02	0.34	-2.04	0.04	0.29

Note, $df = 45$ for t-tests, with the exception of * for 46.

Table 5.9: Multilevel analysis results of self-efficacy across the training sessions.

	Models		
	1 vs 2	2 vs 3	3 vs 4
df	3	1	3
χ^2	11.20	0.22	11.04
p-value	0.01	0.64	0.01
	add training sessions	add group	add the interaction

the training without self-motivation, the with self-motivation training showed more improvement in self-efficacy and self-reported negotiation satisfaction and results.

Table 5.8 shows how well improvement of the training was maintained in the two weeks follow-up. Knowledge improvement was still observed for both training groups. However, self-efficacy showed no differences with pre-training levels in the without self-motivation group, whereas it did in the group with self-motivational cognitions. This group was also the only group to maintain improvements in self-reported negotiation satisfaction and results. These group differences were also confirmed by the significant differences found between the two groups on the pre and follow up improvement.

5.6.2 Training sessions

The multi-level analysis compared the models' ability to fit the self-efficacy data. As shown in Table 5.9, model 4 had the most appropriate fit ($p < 0.05$). The multilevel analyses indicated a significant main effect for sessions and an interaction effect between session and condition. It suggests that the self-motivation statements that the participants heard during the training effectively improved participants' self-efficacy and the training sessions continually increased participants' self-efficacy. Whereas Figure 5.4 shows how self-efficacy in general increased in the training, Figure 5.5 shows the self-efficacy score especially increased for the training group that received self-motivational cognition. The self-motivational statements participants heard during the

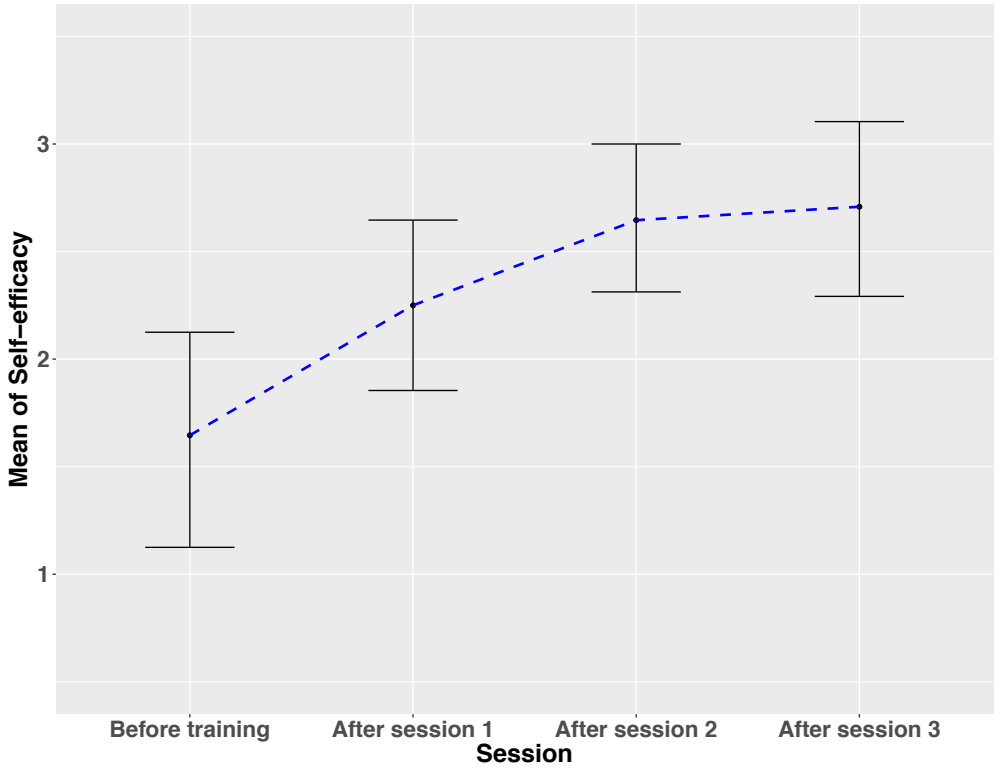

Figure 5.4: Mean (error bar 95% CI) self-efficacy score obtained before the training and in the different sessions for the overall training group.

training, fell in the top four of seven intervals underlying the negotiation attitude scale. See Appendix I for the distribution across the training sessions.

5.6.3 Perceived utility

When comparing scores on perceived utility with scale middle value, participants had attitudes leaning towards the positive side of the scale for both the satisfaction-related utility ($t(47) = 8.83$, $p < 0.001$, $M = 5.22$, $SD = 0.95$) and the effectiveness-related utility ($t(47) = 9.03$, $p < 0.001$, $M = 5.33$, $SD = 1.02$). However, no differences were found between the two training groups for satisfaction-related utility ($t(46) = 1.16$, $p = 0.25$) and effectiveness-related utility ($t(46) = 0.42$, $p = 0.68$).

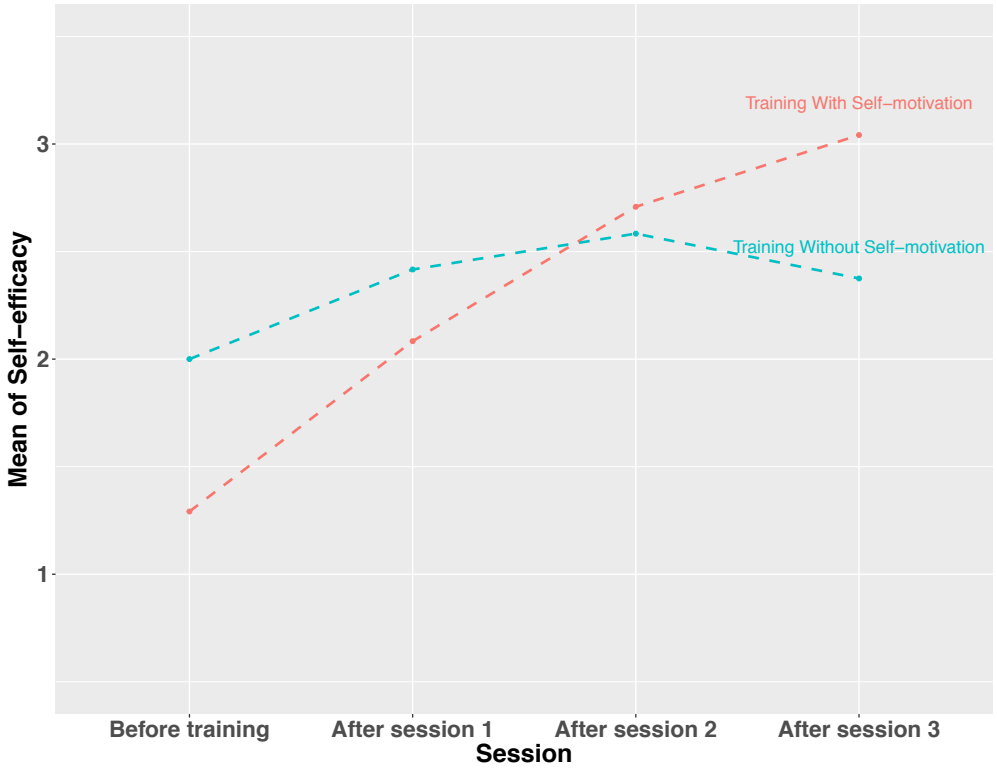

Figure 5.5: Mean (error bar 95% CI) self-efficacy score obtained before the training and in the different sessions for training with self-motivation group and training without self-motivation group separately.

5.7 Discussion and conclusion

In this study, we investigated the efficacy of a virtual reality negotiation training system with virtual cognitions. The results show that the training had a large improvement effect on self-efficacy ($d = 1.13$) and negotiation knowledge ($d = 1.20$) compared to the waiting-list condition. This confirms the first hypothesis. What is more, the training condition with self-motivational statements resulted in a larger improvement effect on self-efficacy ($d = 1.18$) than the training condition that did not include these self-motivational statements, thereby confirming the second hypothesis. All these improvements were sustained at the two-week follow-up. Secondary outcomes also showed improvements between the training and waiting-list conditions for negotiation satisfaction and perceived negotiation results obtained in people's daily life. These improvements were also higher for the group that received the

self-motivational statements than the other training group. No difference, however, was found in the number of times people reported having negotiated before or after the training. Unlike the pilot study [155], where participants rated their satisfaction as neutral and usefulness of the system also as neutral, in this study, attitudes were significantly positive. A possible reason might have been the use of the native language. In the pilot study, non-native English speakers listened to their voice in English, while in the current study, Chinese speakers listened to their voice in Chinese.

The main scientific contribution of the work is the idea of using virtual cognitions as part of a social skills training to provide people with new social skills knowledge, reflections on social interaction, and motivational encouragement. Other existing social skills training systems rarely provide this kind of explanation, reflection, and real-time guidance. Besides the conventional visual experience, the presented training system also gives people thought experiences. Furthermore, this study investigated the effect of self-motivational statements, as a specific type of virtual cognitions, on people's behaviour and self-efficacy. The findings seem to justify it as a new strategy for training in virtual reality. Moreover, in this study, attention was paid to increasing individual's self-efficacy, a factor that is often neglected by training systems. The findings of this study provide a first insight into the efficacy and acceptance of a training system that offers real-time guidance and targets people's self-efficacy. Table 5.10 shows the effect sizes of pre-post measurement found in experiments with negotiation training systems. Following Cohen's classification [167], the first two studies found large effect sizes and the third study found a medium effect size. Top of the effect size list is the current study, which can also be classified as large. It hints the potential effectiveness of the proposed system, and therefore warrants more research in this area.

Like any empirical study, this study has some limitations that should be considered to appreciate the findings. First, the training system was studied following a system approach principle [168]. This meant that the system was viewed as a unified whole. The objective was not to identify the effect of

Table 5.10: Effect size of pre-post measurement of negotiation training systems

Study	Measures	Effect size (η^2)	Cohen's classification
Broekens, et al. (2012)	Negotiation knowledge	0.18	Large
	Conversation skill	0.16	Large
Lin et al. (2009)	Utility score of negotiators	0.14	Large
Ross Jr, et al. (2001)	Score of participants	0.13	Medium
This paper	Self-efficacy	0.24	Large
	Negotiation knowledge	0.26	Large

specific functions on the overall effect created by the system. For example, in the training system, users' self-efficacy levels were taken into account to select appropriate self-motivational statements for each individual. While the results suggest that the system was effective, it is not clear how much this personalisation contributed to this result. Secondly, although the sample size in this study was larger than in the pilot study, the participants were again university students or employees. It is, therefore, not clear to which extent findings generalize to other populations. Thirdly, the self-efficacy measure in this study was simple and general by using a one-item measure, however, it was also suggested that self-efficacy measures ought to reflect a particular context or domain instead of global functioning [141]. In our case, several sub-items could be created targeted to different contexts or perspectives of negotiation.

The work can be extended in several ways. For example, what learning improvement can be obtained when the system is combined with an active component? Would an initial self-efficacy boost, have learners benefiting more from a follow-up unguided negotiation experience with an interactive virtual agent [53]? Also, how sustainable are these improvements? The current study only looked at a follow-up period of two-weeks. Whether training with virtual cognitions could also result in more permanent changes is still an open

question. Work can also focus on extending the system. Here, for instance, the pre-recording process of all statements comes to the fore. Before the start of the formal training in the current system, users have to spend time recording all the negotiation dialogues and virtual cognitions that they will hear during training. To some extent, this effort limits the utility of the training system. However, this limitation could be overcome soon with the introduction of machine learning solutions which aim to imitate any human voice. For example, Mehri et al. [169] propose an unconditional neural audio generation model that uses neural networks to generate audio from training samples. This idea was used by the software app Lyrebird, which claims the ability to mimic any voice from just one minute of sample audio [170]. Besides creating an audio illusion of ones' own voice, work can also focus on creating the illusion of ones' own virtual body. For example, Hülsmann et al. [171] report on a platform with a 3D scanner that they developed to create realistic life-size 3D models or virtual bodies that can mimic or substitute users' real bodies in a virtual environment. In addition to the visual stimulation, Banakou and Slater [131] have also worked on vibrotactile stimulation of the body. They administered this stimulation on the thyroid cartilage when participants heard a pre-recorded voice to create the illusion of speaking by the participant. It remains, however, to be seen if virtual cognitions could also be regarded as illusions of one's own thought while experiencing them or when remembering them later on. Also, what level of presence and agency would people experience when multiple of these illusion technologies are combined? Even more, how could this experience become more engaging? Currently, the users only passively experience the negotiation. A more active role in the negotiation could increase the sense of presence during the training, causing an increase in learning efficacy [172]. One strategy would be to integrate eye-tracking technology into the training system. The content of the virtual cognitions could then be tailored to the objects which people focus their attention on in a virtual environment.

Finally, the use of virtual cognitions could also be beneficial for other

domains such as for therapeutic systems or in gaming for storyline delivery or character development. Could it, for example, enhance the STRIVE system [173]? This system uses virtual reality episodes narrated in first-person to provide soldiers with a feeling of experiencing a stressful event. It already uses a voice-over to deliver psycho-educational knowledge. Extending this with the thought process of the soldiers might potentially also improve their self-efficacy to cope with stressful events.

In conclusion, this study demonstrates the efficacy of a negotiation training system that provides guided learning with the combination of passively virtual reality experience and virtual cognitions. Moreover, these effects were maintained at the follow-up two-week measurement, indicating that the changes in individual's beliefs and gained knowledge are not short-lived.

Chapter

6

The effect of adaptive simulated thoughts in virtual reality on user's eye-gaze behaviour, ownership perception and plausibility judgement

6.1 Introduction

Imagine that you are immersed in a virtual reality (VR) environment from a first-person avatar perspective: Not only are you going through the visual sensory experience of your avatar, but you are also experiencing the cognitive thoughts people might have in avatar's situation. What if these thoughts you hear are adapted to what you look at? Would this adaptation make these thoughts feel more plausible and even feel more like your own thoughts? Besides, would it make virtual cognitions more effective in influencing your behaviour in virtual reality? The findings obtained in the previous chapter indicate that virtual cognitions can indeed enhance self-efficacy, knowledge, and people's behaviour. This chapter, therefore, studies how adaptiveness influences the sense of ownership and plausibility. Furthermore, how these two relate to people's behaviour.

Virtual cognitions are an extension of the more classical virtual reality experience. In the past decades, research on virtual reality focused on the development and improvement of the virtual environment, such as the realism of virtual objects [174], the fidelity of the lighting model [31], the virtual depth-of-field blur [175], and the spatialization of the audio rendering model [176,177]. Besides the external environment surrounding the user in virtual reality, recently, the virtual representation of the user in the virtual environment, i.e. the virtual body, has gained more attention. For example, creating a photo-realistic rendering of users' own physical image into virtual reality [178, 179], or the synchronisation of virtual body movement with user's actual physical movement [125, 180]. The latter is often studied in the context of the virtual body illusion or body transfer [103, 181]. Here, users experience that virtual body as their own body. This illusion is regularly enhanced by using real-time mirror reflections of motor action [182–184] in a virtual mirror. Where virtual bodies are used to give users the experience of another body, virtual cognitions are used to give users the experience of another cognition, i.e. thoughts.

Virtual cognitions are a stream of simulated thoughts people perceive

while emerged in a virtual environment, e.g. by hearing a simulated *inner voice*. They can provide people with information about a topic, reflections on the current situation, or offer motivational encouragement. The inner voice, regarded as "verbal sets, instructions to oneself, or a verbal interpretation of sensation and perceptions" [185], plays a crucial role in conscious thoughts. They are believed to serve various cognitive functions such as self-control [186], self-reflection [99] and so on. People tend to follow the instruction from their inner voice [186, 187]. With the help of a simulated inner voice, individuals might be not only able to perceive the external virtual environment, the behaviour and the events via an avatar, but also the internal thoughts.

Virtual reality, in the form of therapy [84, 188] or training [19], can contribute to change in people's beliefs and behaviour. Besides, virtual cognitions can directly extend users cognitive understanding of the situation. Therefore, virtual cognitions have the promise of an effective strategy for behaviour change. The first support for this tenet can be found in the work of Kang et al. [149]. She had users passively experience giving a public talk in virtual reality. Instead of actually asking people to give a physically talk in front of a virtual audience, she had them listening to a pre-recorded presentation from a first-person perspective. She found that the extent they identified with the virtual person in the experience coincided with the extent they changed their self-efficacy about their ability to give this public talk in real life. The second support comes from the work of Ding et al. [189]. He used virtual cognitions to train people on negotiation. By comparing the trainees with an inactive control group, he found that trainees had improved their self-efficacy, knowledge about negotiation, and their negotiation satisfaction and result. As these effects were still observed multiple weeks after the training, it warns further research into understanding how virtual cognitions work and how its effect can be extended.

The sense of being there in the virtual world, i.e. presence, has been identified as a critical enabler for the success of virtual reality experiences. For example, a higher level of the sense of presence is associated with a

higher level of experienced anxiety [190, 191], which is essential for the success of virtual reality exposure therapy. Understand factors that can enhance presence, therefore, is essential. One such factor is the adaptation between an array of sensory cues. Access to a multitude of these cues enhances people's sense of presence in virtual reality [192, 193]. Once exposed in virtual reality, a virtual cognition is just one among other cues such as the very dominant virtual sensory cues. Therefore, to adapt virtual cognitions to user's viewing behaviour, a system would need to know what the user is looking at. Eye-tracking technology could provide this information. Whereas eye-movement conveys information about people's emotional and mental states [194], it also indicates people's focus of attention. What people perceive, triggers and shapes their thoughts [195–197] as has also been observed in virtual reality where the surrounding material primed people into asking specific questions [198]. Synchronisation, therefore, would lead to offering people virtual cognitions that would appear triggered naturally by the visual cue, and consequently experienced as more plausible to have.

6.2 Theory and Hypotheses

Figure 6.1 illustrates the key concepts in the relationship between adaptive virtual cognitions (VC) and eye-gaze behaviour. Virtual cognitions aim to change people's beliefs by changing how they make sense of the world. It would manifest itself by changes in people's focus of attention (e.g., eye-gaze behaviours). In fact, anyone taken a tour at a museum with a handheld audio guide device has probably experienced this. When the recorded commentary spoke about a specific physical aspect of the artefact, you would look at it.

The center of Figure 6.1 shows the direct effect between adaptive virtual cognitions and people's eye-gaze behaviour (H3). Although providing virtual cognitions could bring many benefits for users, such as receiving more guidance, reflection or encouragement, it also requires one more source to attend, thus brings new challenges for users to deal with selective attention and divided

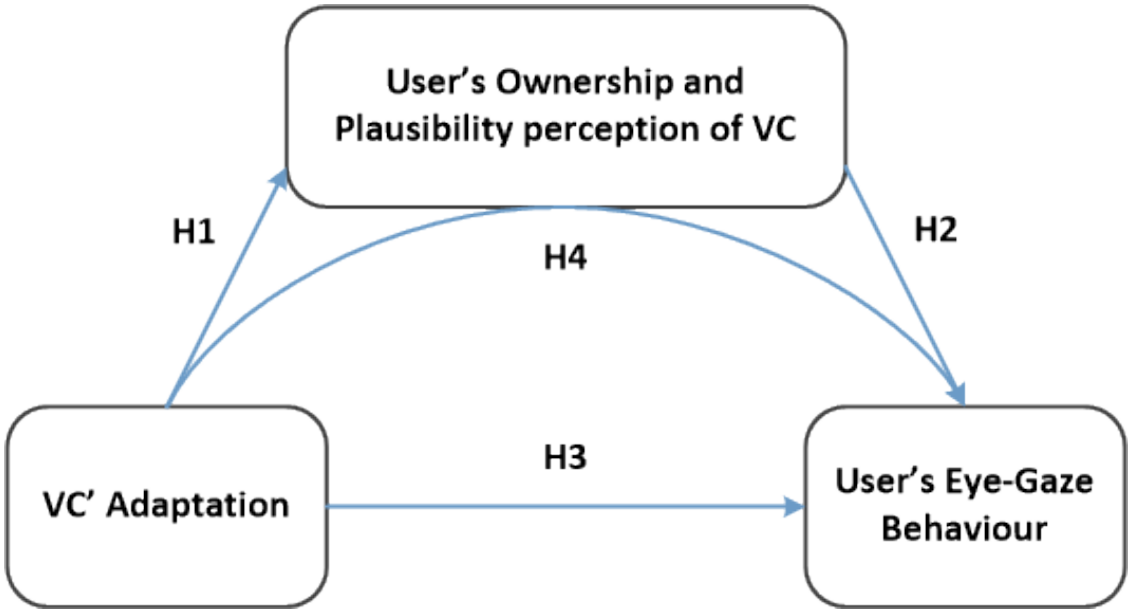

Figure 6.1: Hypothesised relationship between adaptation, ownership, plausibility and eye-gaze behavior

attention. If these sources are not congruent, people might be forced to divide attention across multiple information sources, which imposes additional cognitive load that interference with experience [45]. Whether people select, focus and process the content of virtual cognitions determines whether and to what extent they affect people's behaviour. If virtual cognitions are coherent with other stimuli, people might be able to pay more attention to their content, and consequently, follow up instructions embedded in virtual cognitions, i.e. instructional virtual cognition.

This general effect is mediated by the sense of *ownership and plausibility* of the virtual cognitions (see Figure 6.1; H4). Plausibility illusion is one of the two factors that affect how people experience presence in virtual reality [199]. This illusion is about what is perceived as really happening; in other words, the virtual cognition is an actual cognition, i.e. thought. The other factor is place illusion, referring to the sense of being there [199]. This factor seems less relevant to virtual cognitions as they are less about being in a specific place and more about the person itself. Instead, the concept of ownership is more suitable. It refers to "the sense that I am the one who

is undergoing an experience" [200]. Sense of ownership is closely linked to another concept in virtual reality that receives attention because of virtual body illusion [201–204]. It is the sense of agency, which refers to the feeling of control over one's actions [205]. For voluntary actions, the sense of ownership and sense of agency coincide but are distinct when the sensory experience is passive and involuntary. For example, when some external force passively moves one's arm, the sense of ownership can be still experienced but not the sense of agency [200, 206]. When it comes to thoughts and cognitions, it is hard to say that a person is in direct conscious control of them. However, people would experience them as their own. In fact, when they do not feel this, people might experience what is known as thought insertion, a common symptom of psychosis and associated with schizophrenia, where people feel their thought are not one's own but being inserted into their mind [207, 208]. Framing the effect of inner voice on eye-gaze behaviour as a simple stimulus-response format helps in understanding why plausibility and ownership can moderate this effect. Virtual cognitions are artificial stimuli. The more they resemble the actual stimuli, the more they can elicit the related response. Hence, plausibility and ownership are properties of this resemblance. When they are high, the resemblance is also high. In that case, people would be more inclined following instructions aimed to guide eye-gaze embedded in virtual cognitions (see Figure 6.1; H2).

Adapting the virtual cognitions to the focus of attention (e.g., to user's eye gaze) is expected to bring about a higher sense of plausibility and ownership of the VC (see Figure 6.1; H1). Providing multiple types of sensory stimuli, such as visuals, audios and haptics, has the potential to enhance the sense of presence [193, 209], and task performance. However, this only happens when the stimuli are consistent, as has been observed for visual cues and haptic stimuli [210], and for visual and auditory stimuli in virtual environment [209, 211, 212]. In contrast, when inconsistent, presence, memory recall, and task performance can deteriorate [211]. Therefore, adjusting the virtual cognitions to match the visual stimuli has the potential of making the virtual

cognitions aligned with person's focus of attention, and making them more plausible. Moreover, according to Shimada et al. [206], the sense of ownership can be achieved by the integration of multiple sensory cues, such as the synchrony of visual and proprioceptive cues, or as Slater [199] observed proprioception and visual exteroception. Hence, the adaptation has the potential of increasing the sense of ownership of the virtual cognitions.

Based on the above, four key hypotheses can be formulated as follows:

H1. Compared to non-adaptive, eye-gaze-adaptive virtual cognitions have a positive effect on people's perceived ownership (1-a) and plausibility (1-b) of the virtual cognitions.

H2. An individual's perceived plausibility and ownership of the virtual cognitions are positively associated with the number of eye-gaze shifts after hearing an instructional virtual cognition.

H3. Compared to non-adaptive, eye-gaze-adaptive virtual cognitions have a positive effect on the number of eye-gaze shifts after hearing an instructional virtual cognition.

H4. The effect of eye-gaze-adaptive virtual cognitions on the number of eye-gaze shifts after hearing an instructional virtual cognition is at least partially mediated by people's perceived ownership (4-a) and plausibility (4-b) of the virtual cognitions.

The remaining part of the chapter presents a system that was developed and experiment that was carried out to test these four hypotheses in the context of a pre-therapy for spider and snake phobia.

6.3 System

Virtual reality (VR) environments are being studied and applied in a broad set of application domains, such as for treatment [28,29], education [27,60] and entertainment [183, 213]. One of its core benefits, is the ability to experience real-world scenarios in a safe, controlled and engaging environment. People can transfer the VR experiences to their real world. For example, in virtual

reality therapy for anxiety disorders, people are exposed to virtual scenarios that resemble scenarios they fear in real-life. After these exposures, they are more capable of coping these real-life situations [214]. Virtual reality therapy is a cognitive behavioural therapy. The current emphasis, however, is mainly on the behavioural component. Extending the virtual exposure with virtual cognitions would allow addressing the cognitive component of CBT. Therefore, to test the four hypotheses in a potentially beneficial context, a virtual reality system was developed that could precede a virtual reality therapy for spider and snake phobia aiming to improve people's self-efficacy of coping with the presence of the feared animal.

Following the concept of virtual reality exposure therapy, the following *usage scenario* was constructed. The exposure session consists of three scenes. In the first scene, users are sitting alone in the virtual room, hearing virtual cognitions reflecting on the upcoming appearance of the feared animal, presenting some facts and information about these animals. Self-motivational cognitions accompany these reflections. The second scene consists of actual exposure to the feared animal. The feared animal moves slowly from out a sofa in the corner to the centre of the room (Figure 6.2). Users could explore the virtual room or look at the animal, and meanwhile are exposed to the virtual cognitions. Finally, the animal crawls out of the room and disappears from the users' sight. In the last scene, users are again alone in the virtual room like the first scene. They hear the virtual cognitions that review the process of past exposure, their performance and also encourage them affirmatively.

For the usage scenario, we designed *virtual cognitions* as follows. Users could hear three types of virtual cognitions, as shown in Table 6.1: (1) a factual statement about the feared animal, such as "A spider is just a type of animal people are not so familiar with, but it does not mean you should feel afraid of it.", (2) self-motivational statements of handling the fear-animal, e.g. "You are strong enough to handle that.", and (3) instructions to encourage specific-gaze behaviour, e.g. "Try to look at the spider a bit longer". Each type of virtual cognitions has two versions based on the condition: eye-gaze-

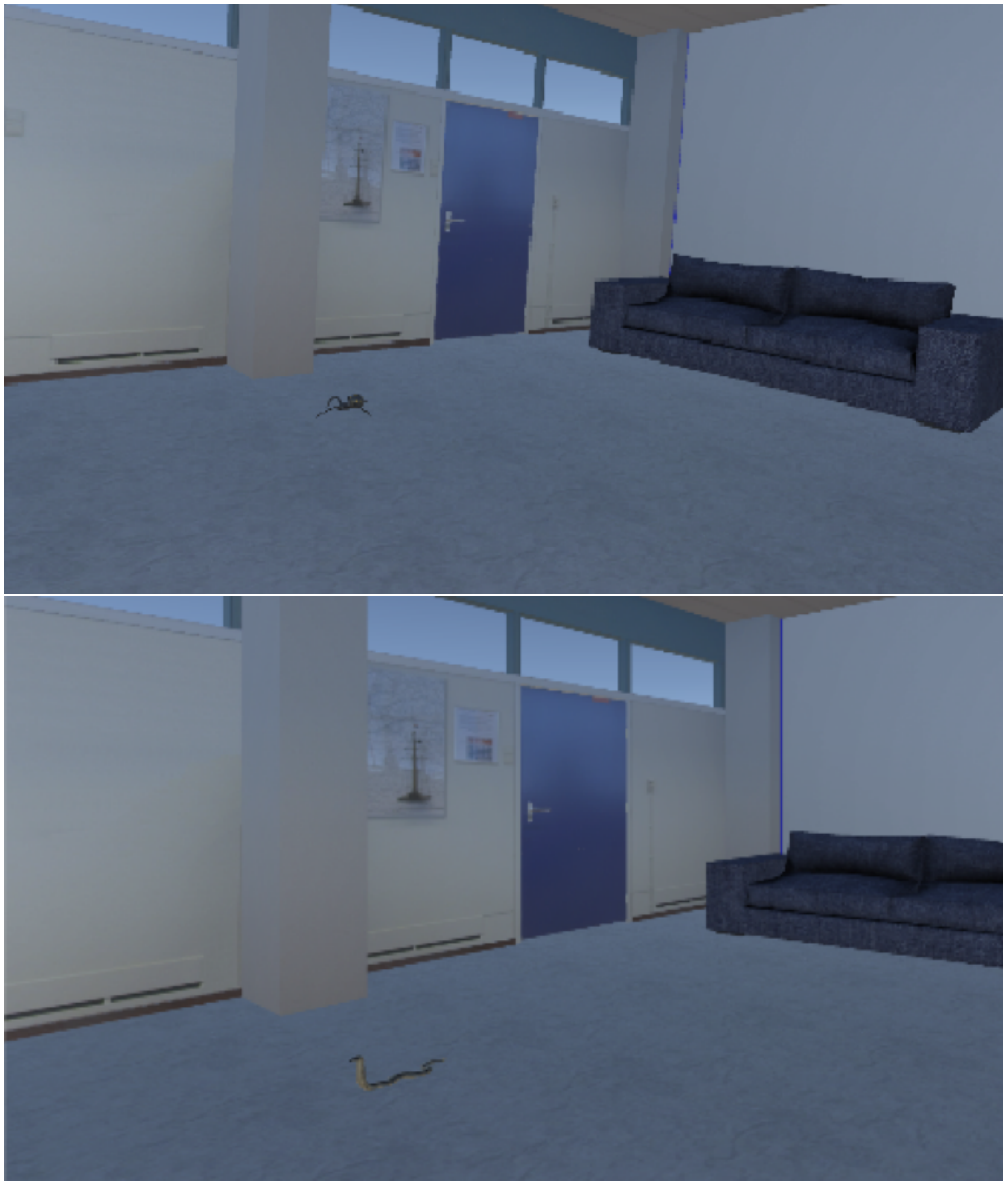

Figure 6.2: The screen shot of virtual reality exposure from the perspective of users: spider condition (above) and snake condition (bottom)

adaptive virtual cognitions and non eye-gaze-adaptive virtual cognitions. In the first and last scene, users only hear the generic virtual cognitions, i.e. non eye-gaze-adaptive virtual cognitions, which include the first two types of virtual cognitions: factual and self-motivational virtual cognitions. Only in the second scene, which includes the feared animal, does the system use adaptive cognitions that include all three types of virtual cognitions. Once immersed in a virtual room, the system uses eye-tracking technology embedded in a

head-mounted display (HMD) to register whether or not users are looking at a virtual representation of the feared animal. Consequently, the system could trigger an animal-related virtual cognition.

For testing the hypotheses, two versions of the systems were created: one that has eye-gaze adaptive virtual cognitions and one that only has generic virtual cognitions. In the eye-gaze adaptive version, the virtual cognitions that users heard depended on where they were looking at. If users were looking at the spider, the virtual cognitions acknowledged that they were looking at it, described its movement, and encouraged them to continue looking at it. In the non-adaptive version, no acknowledgment was included about whether they were looking at the spider or not. As the examples show in Table 6.1, the eye-gaze adaptive version uses a formulation that assumes a specific eye-gaze fixation (e.g, 1 second), whereas the generic version use a formulation that does not make such assumptions. Coping strategies of people that fear these animals might differ, for example, they might avoid looking at the animal or excessively look at the animal. Therefore, at the start of the second scene, the instructional virtual cognitions encourage users to look at the animal, later on in the scene, instructional virtual cognitions encourage users to look away from the animal.

A pilot study with 4 participants (1 Female, age from 25 to 38, $M = 30.25$, $SD = 5.56$) was conducted to empirically establish the number of sentences of each type that the individual would hear in the second scene during the virtual exposure. For the two states: looking at the feared animal and not looking at the feared animal, the average number of sentences that played were 13 and 18 separately, resulting in the corresponding numbers for each type of virtual cognitions in Table 6.1. These numbers were also used in the actual experiment.

Table 6.1: Three types of virtual cognitions used in the system

Type	State	Adaptive	Non-adaptive	N
Factual statements about the feared animal	When participants are looking at the feared animal	To some extent, the snake you are looking at seems ugly, but it's ok, you can face it.	To some extent, a snake seems ugly, but it's ok, you can face it.	8
	When participants are not looking at the feared animal	Avoid watching the snake like what you are doing now is not helping, it is avoidance.	Avoid watching a snake is not helping, it is avoidance.	13
Instructions to encourage specific gaze behaviour	Instruction of looking back to the feared animal	It's fine to feel a little bit fear but it can be overcome. Trust yourself. You are brave than you believe. Turn to look at the snake. Just do it.	It's fine to feel a little bit fear but it can be overcome. Trust yourself. You are brave than you believe. Take a chance to look at the snake is a cleverer way.	5
	Instruction of looking away from the feared animal	Do not keep an eye on the snake all the time like now! Just do what you want to do.	It's not necessary to keep an eye on the snake all the time, just do what you want to do.	5
Self-motivational statements of handling the fear animal		You are so brave that you can look at the snake like now.	You are so brave that you can look at a snake.	5

6.4 Method

To test the hypotheses, an empirical experiment with 24 participants was conducted. The experiment had a within-subject design, where all participants were exposed to both the eye-gaze and non eye-gaze-adaptive virtual cognitions conditions. The order of the two conditions was randomised. Each participant was exposed to another animal in each condition. This reduced the risk of a potential carry-over effect associated with the experiences obtained with a specific animal. For each participant, the two animals were randomly assigned to the two conditions. The study was approved by the human research ethics committee of Delft University of Technology (Application ID: 577) and pre-registered prior to accessing the data (OSF osf.io/q58v4).

6.4.1 Participants

27 participants (15 males, 12 females) were recruited throughout the university campus via e-mail or approached personally. Three participants dropped off during the experiment owning to some personal arrangement reasons. The ages of the remaining 24 participants (14 males, 10 females) ranged from 22 to 36 ($M = 27.83$, $SD = 3.2$). They all spoke fluently Mandarin. 2 participants with bachelor's degree, 16 with master's degree, and 6 with Ph.D. degree. 29.1% of participants (7/24) have experienced virtual reality before, the remaining have not.

Although the system was designed with the idea of a pre-treatment of spider or snake phobia, because of ethical reasons, participants with a high level of spider or snake fear were excluded from the study. Exclusion criteria were set to 23.76 and 24.44 for the Spider questionnaire (SPQ) and the Snake questionnaire (SNAQ) respectively [215]. Fredrikson et al. [215] reported these as the mean score for phobia participants in their study. None of the participants crossed this threshold (SPQ Range [2.0, 18.0], $M = 10.0$, $SD = 5.26$; SNAQ Range [4.0, 22.0], M=12.75, SD=6.24).

6.4.2 Materials and measures

6.4.2.1 Primary measures

Plausibility of the virtual cognitions. To examine how plausible people thought the virtual cognitions were, a 3-item plausibility questionnaire was used, covering three key dimensions of plausibility illusion: reactivity, credibility, relativity [199, 216]. This questionnaire was an adaptation from the one used by Millevill-Pennel and Charron [217]. All the items were rated on a scale from -3 (very bad) to 3 (very good). See Appendix K for all questionnaire items.

Sense of ownership of the virtual cognitions. To investigate the sense of ownership of the virtual cognitions, a dedicated questionnaire was created that was inspired by several existing questionnaires [218, 219]. All 5 items were rated on a scale from -3 (totally disagree) to 3 (totally agree). See Appendix K for all questionnaire items.

Number of eye-gaze shifts. Besides the two self-report measures mentioned above, as a behavioural measure, the number of times whether or not people shifted their eye-gaze within a time frame of 3 seconds after hearing an instructional virtual cognition were counted automatically by the system.

6.4.2.2 Secondary measures

Self-efficacy of handling spiders/snakes. Following the study of Bouchard, Stéphane, et al. [220], a one-item perceived self-efficacy measure was used. The question was formulated as: "On a scale of -5 to 5, to what extent do you feel that you can face a situation where you are in the presence of one or many spider(s)?" Or snakes in the case of the snake exposure. The item was rated on a scale from -5 (highly certain cannot do) to 5 (highly certain can do).

6.4.3 Procedure and apparatus

The study consists of four phases: pre-measurement, audio recording, exposure, and post-measurement. In the first phase, participants signed an informed consent form, and completed a self-efficacy questionnaire, a fear with handling spiders (SPQ) and snakes (SNAQ) questionnaire, and a form for collecting biographical data (e.g. age, gender, education, previous virtual experience). After this, participants proceeded to the audio recording phase. Here participants read out the complete set of 206 virtual cognitions which was recorded with a pair of In-Ear Binaural microphones (SP-TFB-2 Sound Professionals). Virtual cognitions were written in Mandarin to match the participants' mother tongue. The complete set of virtual cognitions is online available both in Mandarin and in English[1]. An example can be found in Appendix J.

Considering people perceive the sound of their inner and outer voice different, with clear individual variance [153], after recording, participants were asked to listen to a part of their voice recordings and instructed to set seven sound parameters such as pitch, speed, echo to make the recordings sound as their inner voice. These sound parameters settings were later used to create the virtual cognitions that were provided in the exposure phase.

Two measures were in place that reduce potential carry-over effects from the recording phase to the exposure phase. First, the order of the individual virtual cognitions was randomised. Second, at least one-day interval was taken between the second and the third phase, i.e. exposure phase. Here participants, in both conditions, wore the FOVE 0 HMD, which is equipped with infrared eye-tracking technology (tracking accuracy less than 1 degree, frame rate 120 fps), and with display a resolution of 2560 $\times$ 1440 pixels, with a field of view up to 100 degrees, frame rate of 70fps. In addition, they wore the same pair of In-Ear Binaural microphones to hear virtual cognitions.

The virtual room was created in Unity3D. As mentioned before, the ex-

[1]These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is `10.4121/uuid:f6b30e6f-c02a-4e11-b6e8-71953a1ca55b`

posure considered out of three scenes, and only in the second scene included the animal. In the eye-gaze condition, participants were exposed to eye-gaze adapted virtual cognitions, while in non eye-gaze-adaptive condition to randomly selected generic virtual cognition. After the third scene, participants completed questionnaires about ownership and plausibility of virtual cognitions, after which again went through three virtual reality scenes but this time for the other experimental condition. During the exposure, the number of eye-gaze shifts participants made after hearing the instructional virtual cognitions was counted. The experiment ended with post-measurement phase, where participants were asked to complete a questionnaire that assess the plausibility and sense of ownership of the virtual cognitions, and again their self-efficacy of handling spiders and snakes.

6.4.4 Data preparation and analysis

6.4.4.1 Data preparation

Reliability analysis of the questionnaires for plausibility and sense of ownership of virtual cognitions. Cronbach's alpha showed acceptable levels of reliability for plausibility (mean $\alpha = 0.79$; 0.77 and 0.81 for the first and second exposure respectively) and the sense of ownership questionnaire (mean $\alpha = 0.85$; 0.81 and 0.89 for the first and second exposure respectively). Hence, subsequent analyses used the mean value of the items.

6.4.4.2 Analysis

A Bayesian approach was used to analyse the data. Compared to the frequentist approach, it has been associated with richer and more informative inferences, performing well with small sample sizes, no reliance on sampling distributions, and p-value [221]. By considering the posterior probability distribution of the parameter values supporting and those opposing the hypothesis, the analysis estimated the level of credibility that could be attributed to each hypothesis and its alternative. Also, the analysis estimated the 95%

Highest Density Interval (HDI) to summarise the interval of the most credible values.

All analyses were carried out with R version 3.4.2. The Bayesian First Aid package [222] was used to investigate the effect of adapting virtual cognitions to eye-gaze on people's perceived plausibility and ownership of the virtual cognitions, and the numbers of eye-gaze shifts after hearing an instructional virtual cognition. This package is an extension of the Bayesian Estimation Supersedes the T-test (BEST) package [223, 224], which works as a Bayesian estimation alternative to the t-test. The analysis used the default minimally informative priors from the package, namely: standard deviations set to 1000, and exponentially distribution for the ν parameter set to 30.

The bmlm package [225] was used to examine the within-subjects mediation effect of the fourth hypothesis. The analysis used the uninformed default values as suggested by Vuorre and Bolger [225] as priors, namely: regression parameters, the prior distributions were zero-centered, with the standard deviations of 1000; for the subject-level effects' standard deviations a Cauchy distribution was used set to 50; for the correlation matrix a LKJ prior ν was used and set to 1.

For all the experiment data, the R markdown files can be found online[1].

6.5 Results

Table 6.2 presents the comparison results for the eye-gaze adaptive and the control condition, i.e. the non-adaptive condition. The mean of the credible values shows an increase of 1.24 in eye-gaze shifts for the adaptive condition, with a 95% HDI of 0.43 and 2.02, which does not include a zero difference as 99.8% of the credible values are above zero. Correspondingly, the data set gives only a 0.3% support to the alternative hypothesis, i.e. zero or a reduced eye-gaze shift. Table 6.2 gives similar information about

[1]These files are stored for public access on a national database for research data with the 4TU Center for Research Data in the Netherlands. The DOI to this storage is `10.4121/uuid:f6b30e6f-c02a-4e11-b6e8-71953a1ca55b`.

the sense of ownership of the virtual cognitions. In the eye-gaze adaptive condition, an increase in ownership was observed, with a 0.55 mean difference and 95% HDI [0.31, 0.80] that excludes zero. Almost 100% of the credible values for the difference are above zero, and consequently, there is almost 0% support for the alternative hypothesis. However, the data gives less severe credibility to a difference in the plausibility of the virtual cognitions between the two conditions. 75.3% of the credible values of the posterior probability distribution support an increase in plausibility, while 24.7% not.

Table 6.3 shows the correlation between the ownership of virtual cognitions and eye-gaze shift behaviour. The credibility of the positive association between them as 95% HDI [-0.15, 0.43] does not exclude zero or negative values. 82.0% of the credible values indicate a positive association, and 18.0% not. In addition to this, Table 6.3 also shows estimates for a mediation effect that ownership might have on the direct relationship between eye-gaze adaptiveness and eye-gaze shift behaviour. As shown in Figure 6.3, after taking indirect ownership relationship into account, the mean value for the direct effect changes from 1.09 to 0.80. Additionally, 80.5% of the credible values for indirect effect change indicate a reduction, while 19.5% not.

The data gave relatively less credibility to a mediation effect for plausibility. As Table 6.3 shows the 95% HDI for the two slopes did not exclude zero or negative associations. With only 56.8% of credible values suggesting a positive association between plausibility and eye-gaze behaviour. Likewise, as Figure 6.4 shows, mean estimate for direct effect barely changed only from 1.10 to 1.06. Nevertheless, 59.3% of the posterior distribution support a reduction in the direct effect, while 40.7% not.

Analysis of people's self-efficacy of handling spiders and snakes suggest an increase between pre and post measurement. For handling spiders, the mean increase was 1.6 with 95% HDI [0.7, 2.5], while for snakes, it was 2.7 HDI [1.4, 4.0]. In both cases, almost 100% of the posterior distribution was above zero.

Table 6.2: Results Bayesian t-tests – eye-gaze adaptive vs. Non eye-gaze-adaptive virtual cognitions

	Mean [HDI] (SD)				
	Adaptive (N=24)	Non-adaptive (N=24)	MD* [HDI]	Effect size d [HDI]	MD* probability below and above
Number of eye-gaze shift	3.44 [2.60, 4.28] (0.42)	2.37 [1.65, 3.08] (0.36)	1.24 [0.43, 2.02]	0.72 [0.15, 1.41]	0.3%< 0 < 99.7%
Ownership	1.68 [1.33, 2.03] (0.18)	1.12 [0.67, 1.60] (0.24)	0.55 [0.31, 0.80]	0.99 [0.47, 1.50]	0%< 0 < 100%
Plausibility	1.41 [1.04, 1.76] (0.18)	1.35 [0.86, 1.82] (0.24)	0.080 [-0.15, 0.31]	0.15 [-0.26, 0.59]	24.7%< 0 < 75.3%

Note. HDI = 95% high-density interval

Note. MD means Mean difference

Table 6.3: The result of correlation between parameters and the mediation effect of ownership and plausibility

	Correlation		Mediation	
	Correlation [HDI]	Probability below and above	Mean [HDI] (SD)	Probability below and above
Ownership	0.14 [-0.15, 0.43]	$18.0\% < 0 < 82.0\%$	0.29 [-0.34, 0.97] (0.34)	$19.5\% < 0 < 80.5\%$
Plausibility	0.03 [-0.27, 0.32]	$43.2\% < 0 < 56.8\%$	0.04 [-0.26, 0.41] (0.16)	$40.7\% < 0 < 59.3\%$

Note. HDI = 95% high-density interval

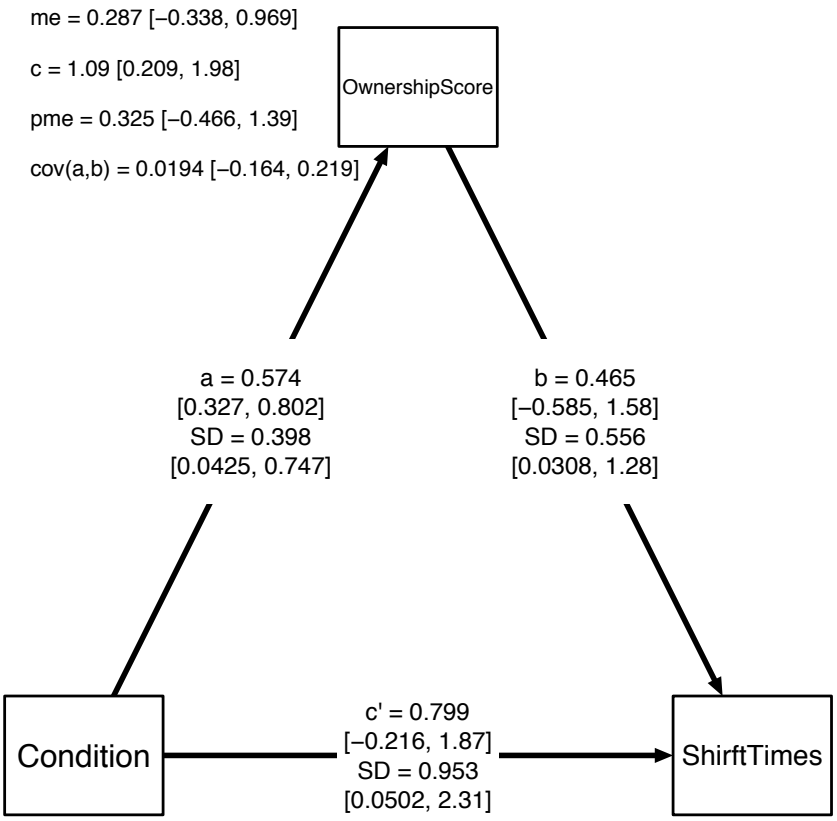

Figure 6.3: Path diagram with point estimates (posterior means) of the parameters and associated 95% intervals (in square brackets below estimates)

6.6 Discussion

This study examined whether adapting virtual cognitions to individual's eye-gaze affects people's perceived ownership and plausibility of these virtual cognitions, thus influencing the numbers of eye-gaze shifts after hearing an instructional virtual cognition. The experiment shows credible support for hypotheses 1-a and 3, i.e. that compared to non-adaptive, eye-gaze adaptive virtual cognitions have a positive effect on people's perceived ownership of the virtual cognitions and the numbers of eye-gaze shifts after hearing an instructional virtual cognition. For plausibility (H1-b), the analysis provides relatively less strong credible support, only 75.3% in support, and 24.7%

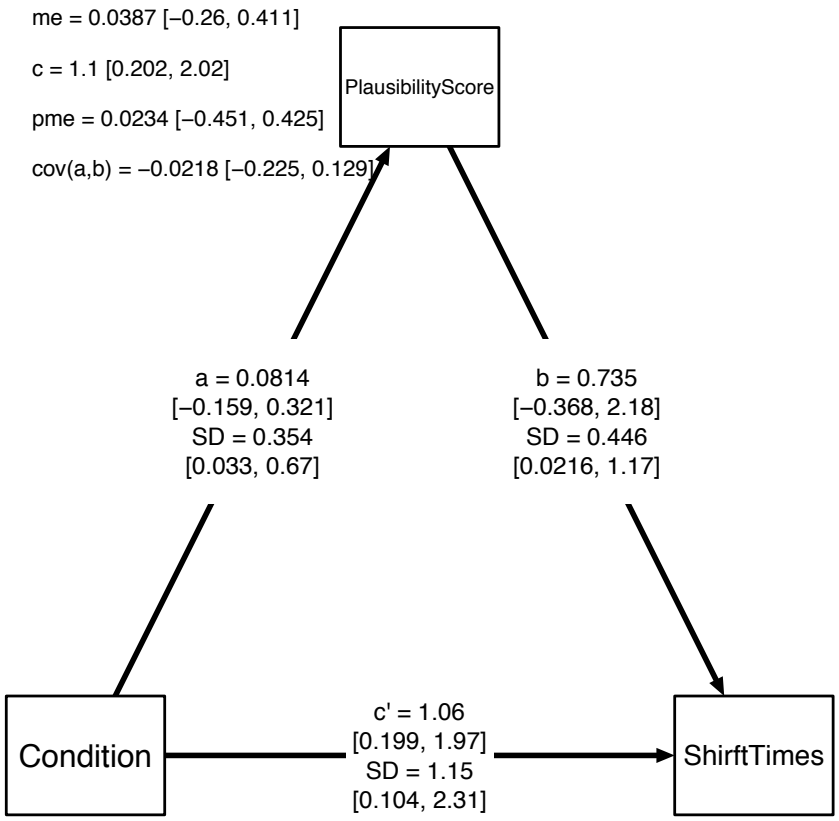

Figure 6.4: Path diagram with point estimates (posterior means) of the parameters and associated 95% intervals (in square brackets below estimates)

opposing it. The finding shows a similar pattern for the relationship between on the one hand, ownership and plausibility of the virtual cognitions and on the other hand, the numbers of eye-gaze shifts after hearing an instructional virtual cognition. While support in favour of a positive association for ownership was 82.0% (H2-a), for plausibility it was merely 56.8% (H2-b). The analysis also provided some credible support for the fourth hypotheses, the mediating effect of ownership (H4-a) and plausibility (H4-b) that could partly explain the increase in eye-gaze shifts when virtual cognitions become eye-gaze adaptive. Support for ownership mediation was 80.5%, while for plausibility a mere 59.3%. Although these findings are sometimes less strong, they seem overall in favour of all hypotheses, especially the ones related to ownership.

Like any empirical study, this study has some limitations that should be considered. First, a confounding variable for the difference between the adaptive and non-adaptive condition was the co-manipulation of cognitions that used information about the person's eye-fixation and generic formulated virtual cognitions. It ensured that participants in the control condition were not confronted with conflicting virtual cognitions, e.g. while not looking at the snake hearing "Stop looking out for the snake all the time. Turn your gaze away!". Removing such potential artificial conflicts by offering generic cognitions resulted in plausible cognitions in both conditions, and hence likely led to less strong support for plausible related hypotheses. A second limitation is a potential error in eye-gaze shift counting caused by the accuracy of the eye-tracking device. For example, whereas people might have looked above the spider, it might have been classified as looking at the spider. Although this might not have systematically biased measurement towards one of the conditions, it could have resulted in some conflicting virtual cognitions in the adaptive eye-gaze conditions. Still, despite this potential limitation, the findings support the superiority of the eye-gaze adaptive condition. The third and final limitation was the use of non-phobic patients in this experiment because of ethical constraints. Therefore, caution should be taken when generalising the findings to this population. Still, the observed improvement in self-efficacy is promising.

This study can be extended in many directions. First, besides increasing the plausibility and ownership of virtual cognitions, other mechanisms could be explored that influence the effect of virtual cognitions. Potential mechanisms might be the perspective-taking to hear the virtual cognitions or the pronouns to refer to the self within the virtual cognitions. For instance, Slater et al. [226] argued that different perspective-taking to hear and observe can lead to people doing, feeling and thinking differently. Myers et al. [227] found that when people were instructed to taking difference perspective their attitude towards helping others also changed. Kross et al. [128] indicated that using a different perspective to refer to the self during introspection can influence people's

ability to regulate their thoughts, feelings, and behaviour. Similar effects have been observed in virtual reality, when people experience from a first-person perspective the world of a person with another skin colour [228, 229], a child [103, 125], or of a superhero [230]. This has often been done by giving people a virtual body of a specific individual. Could something similar be accomplished with virtual cognitions? Until now, research has focused on exposing people to virtual cognitions that match their own inner voice. What would happen if people are exposed to cognitions that are clearly alien to their own? For example, Banks et al. [231] exposed people to the world of someone with schizophrenia, including both audio and visual hallucinations. Combining virtual cognitions and virtual body, therefore, could potentially give people new experiences. For example, the work of Slater et al. [103] could be extended by exposing adults to cognitions of a child in addition to giving them the body of a child.

Furthermore, during the therapy session for snake or spider anxiety, the therapist needs to know whether patients are actually looking at the animal, and not just closing their eyes [232–234]. Eye-tracking technology might be able to detect this. Additionally, instead of a snake or spider phobia, future research could also explore the feasibility of virtual cognitions in other application areas, such as social skills training, the treatment of autism, and education. Besides studying virtual cognitions, this study also shows the potential of using eye-tracking information in virtual reality. Further research might, therefore, explore the experience when other elements in the virtual world react to people's eye-gaze. For example, van Ginkel et al. [235] adapted the behaviours of a virtual audience depending on eye-gaze of the user that gave a public talk.

6.7 Conclusion

This chapter demonstrates that adapting virtual cognitions to individual's eye-gaze is likely to have a guiding effect on people's eye-gaze behaviour in

virtual reality and to enhance people's perceived ownership of the virtual cognitions. Its main contribution can be summarised as providing initial empirical evidence about the effect of the eye-gaze adaptive virtual cognitions technique. A technique with the potential of enhancing the effectiveness of virtual cognitions as a new training or intervention method.

Chapter

7

Conclusions and Discussion

7.1 Conclusion

This thesis proposes a new social skills training approach that provides virtual cognitions in virtual reality. To begin with, a systematic literature review was conducted to get an overview of the state-of-the-art of technology-supported systems for social skills training (Chapter 2). Following this, how people perceive the sound of their inner and outer voices was studied (Chapter 3), the effects of offering virtual cognitions in the context of negotiation skills training in virtual reality were examined (Chapter 4, 5), and finally the idea of virtual cognitions was expanded on, adapting them to individual's eye-gaze (Chapter 6). The studies were designed to answer the main research question:

How can we develop a virtual reality exposure system with virtual cognitions that fosters people's behaviour and beliefs during the training, and what impact does such a system have on its users afterward?

From this main research question, one sub-question and four hypotheses were derived. The conclusions of the thesis are structured by an examination of the arguments for these sub-questions and hypotheses as follow:

Q1: What kind of social skills training systems have already been developed and what are they composed of?

To answer the first question, a systematic literature review was conducted, identifying 122 publications with 113 systems. The analysis shows that the majority of training systems were screen-based applications, with virtual reality technology being the most frequently observed. The systems most often targeted communication skills. In terms of functions, support for learning-by-doing was the most observed function in the systems. Systems focusing on facial expression or using video modelling technology provided the largest number of functions. Finally, the studies, including 30 studies with a randomized controlled trial design, reported overwhelmingly positively regarding the systems' impact. Still, most studies only used a quasi-experimental design based on self-report measures.

As the systematic literature review indicated, that the majority of studies reported positive results, the work presented in this thesis moved forward to explore the effectiveness of using virtual reality training systems on improving social skills. Here, the training system provided users with a stream of thoughts that simulated a inner voice. Therefore, the first step was to investigate the method to simulate the inner voice, leading to the first hypothesis:

H1. People perceive their inner voice to sound different from their outer voice.

The first hypothesis was tested by conducting an empirical study in which participants recorded and adjusted the sound parameters for their inner and outer voice. Using a specially developed audio recording and modification software tool, 15 participants set key sound parameters to match their own voice recording with their perception of either their own inner or outer voice. After reading aloud nine sentences, they modified seven sound parameters of the recordings: pitch, speed, echo, and volume of sound on four frequency bands (20-320Hz, 320-1280Hz, 1280-5120Hz, and 5120-20480Hz). The result of the study indicates that inner and outer voice are perceived differently, which confirmed the hypothesis. Also, individual variations were found for the perception of inner and outer voice differences. For developers who want to simulate inner voices in a virtual environment, these findings suggest that a person's inner voice has its own distinct characteristics compared to their outer voice. The volume setting for the frequency band of 1280-5120Hz can be based on group perception, whereas for speed and echo settings it might require individualization.

After exploring its sound parameters, the concept of inner voice was used to create virtual cognitions for training. This, together with simulated speech, was expected to enhance the outcome of the training. It resulted in the following hypothesis what was set within the context of a negotiation training.

H2. Virtual reality negotiation training with virtual cognitions combined with simulated speech improves negotiation knowledge

and self-efficacy of negotiation compared to no training.

The second hypothesis was confirmed by conducting a randomized controlled trial to compare a training group with a waitlist control group. Forty-eight participants were recruited and randomly assigned to one of these two conditions. This study consisted of four phases: pre-training, training, post-training and follow-up phase. In the training phase, the participants were randomly assigned to either the waitlist group or training group. Those in the training group were given the virtual reality negotiation training consisting of three consecutive sessions. Meanwhile, the participants in the waitlist group were not given any negotiation training. The results show that the training had a strong positive effect on self-efficacy and negotiation knowledge compared to the wait-list condition. Moreover, all these positive effects were sustained at the two-week follow-up.

After establishing the general effect of virtual cognitions, the work moved forward to explore the effect of one specific type of virtual cognitions: self-motivational statements, especially its effect on self-efficacy as a type of verbal persuasion. It led to the hypothesis 3:

H3. Virtual cognitions with self-motivational statements improve self-efficacy more than virtual cognitions without self-motivational statements.

Support for the third hypothesis was established through a between-subjects design experiment, simultaneously conducted with the last experiment, in which participants experienced one of the two distinct training conditions: a training with self-motivational or without self-motivational cognitions. For each training condition, 24 participants were recruited. After each session, participants were asked to finish an online questionnaire to measure their self-efficacy and negotiation confidence. The results suggested that the training condition with self-motivational statements resulted in a larger improvement effect on self-efficacy than the training condition that did not include these self-motivational statements. Additionally, the improvements

observed after the training could still be observed two weeks later.

After establishing the impact of different types of virtual cognitions, the thesis' work investigated the effect of matching cognition with people's visual attention. It led to hypothesis 4:

H4. People's eye-gaze behavior is more likely to follow the instruction embedded in eye-gaze adaptive virtual cognitions than non eye-gaze-adaptive virtual cognitions.

The fourth hypothesis was examined in an empirical study whereby eye-gaze adaptive virtual cognitions were provided to users during virtual reality exposure to a spider or snake. An experiment with 24 participants was conducted to explore the effect of adapting virtual cognitions on an individual's eye-gaze behaviour during exposure. The experiment consisted of four phases: pre-measurement, audio recording, exposure, and post-measurement. In the exposure phase, a within-subject design was used, thereby the order of conditions was counterbalanced. Participants randomly completed two conditions: VR exposure with eye-gaze adaptive and with non-eye-gaze adaptive virtual cognitions. In the non-adaptive condition, participants heard randomly chosen virtual cognitions. In the other condition, participants were exposed to the virtual cognitions adapted to their eye gaze with aim of steering their attention toward or away from the animals in the virtual world. The results show credible support for the hypothesis; compared to non-adaptive, eye-gaze adaptive virtual cognitions had a positive effect on the numbers of eye-gaze shifts after hearing an instructional virtual cognition. Also, some credible support was found for an increase in people's perceived ownership and plausibility of the virtual cognitions.

7.2 Limitations

To fully appreciate the findings presented in this thesis, it is important to carefully consider the limitations of the studies described.

The first limitation is the result of the chosen recruitment strategy. In

the thesis, all empirical studies, with the exception of the online study of the negotiation knowledge video test mentioned in Chapter 5, recruited solely university students or employees. It is, therefore, not clear to which extent our findings generalize to other populations.

In this thesis we only compared our social skills training with virtual cognitions to a waitlist, therefore, further research should compare our systems to other existing methods, such as books or other computer-based training approaches.

Furthermore, the studies in this thesis focused mainly on investigating the outcome of the intervention. To investigate this, a holistic system approach [168] was followed. Therein lies the second limitation, as this meant that the system was viewed as a unified whole. Less attention was paid to identify the effect of special functions or components on the overall outcome. Therefore, it limits our capability to understand the mechanism determining the outcome of the intervention.

In addition, a theoretical assumption regarding the effect of virtual cognitions is that they possess the ability to mimic people's actual inner voice during virtual reality exposure. Although we tried to investigate the connection between virtual cognitions and one's inner voice by using subjective questionnaires, the measurement was restricted to the cognitive level and did not collect neurological measures that would have allowed to examine this assumption.

Moreover, in this thesis, the efficacy of virtual reality training with virtual cognitions is limited to social skills training and pre-therapy for spider or snake phobia. Still, the positive effect, warrants further research into other domains, for example, entertainment.

7.3 Contributions

This thesis studied the implementation of virtual cognitions as part of negotiation training and explored the effects of adapting these virtual cognitions

to other visual stimuli. The scientific and societal contributions are discussed below.

7.3.1 Scientific Contributions

This thesis proposes a new intervention for training social skills that provides people with both a perceptual (mainly visual) experience and a cognitive experience. Various social skills training systems focus on providing people with opportunities to practice certain encounters or on teaching people what to do and how to act, with no regard for establishing an individual's understanding of the underlying reason for behaving in a certain way. Moreover, as most of the existing training systems focus on the training of skills, they often neglect the importance of the individual's own confidence, motivation and willingness to participate in social interaction (e.g., the study of Broekens et al. [19] that focused on the training of negotiation skills). The intervention proposed in this thesis pays special attention to people's understanding of social interactions and their self-efficacy of engaging in them.

Moreover, the proposed intervention is not restricted to social skills training. In addition to practicing negotiation skills, the thesis also applied virtual cognitions to pre-therapy for spider and snake phobias. It can potentially also be extended to the therapy itself or other domains include entertainment. Furthermore, the study on the sound parameter settings of the inner and outer voice provides a preliminary method to investigate the difference in characteristics between the inner and outer voices.

In general, there is a need for more empirical user studies that investigate effects of virtual reality on human's cognition and behaviour [236–238]. For the scientific field of virtual reality, this thesis provides empirical evidence of effects that the provision of virtual cognitions can have on user's (negotiation) knowledge, (negotiation) behaviour, self-efficacy, perceived plausibility and ownership. This provided some further insights in these concepts and how virtual reality can support a scenario-based learning process, advancing mastery and vicarious experiences.

7.3.2 Societal Contributions

Aside from the scientific contributions, this thesis might also be interesting for a broader societal audience. It describes an intervention that could be applied in fields such as education, entertainment and therapy. This research is aimed at aiding developers and designers of virtual reality systems for training or exposure therapy. However, indirectly, the main societal contributions are for the users or even patients that virtual reality exposure training or therapy targets, including those suffering from social phobia or other phobia.

7.3.2.1 Users

The thesis describes the idea of providing a mix of mastery experience and vicarious experience in virtual reality via passive virtual reality exposure with virtual cognitions. For people with social skills deficits, social phobia, or spider phobia, actively facing a social interaction, such as giving a presentation in front of an audience, even a small audience, or being in a room with a real moving spider might be far beyond their willingness and confidence. Moreover, only offering users the opportunity to practice without sufficient explanation, reflection and guidance might backfire, as this kind of active experience could lead to a failure experience that decreases a person's self-efficacy [141]. From this practical perspective, our method which provides passive virtual reality exposure with virtual cognitions could work as a soft, gradual, and practical intervention.

7.3.2.2 Developers & designers

The taxonomy presented in chapter 2 of this thesis could serve as a starting point for developers and designers in the social skill training systems fields to position their work. It could also help them to identify potential opportunities and offer inspiration to design, develop and evaluate new systems.

Another main contribution of the study is the insight into the creation of virtual cognitions and the implementation of virtual cognitions in virtual

reality training. The study proposes that virtual cognitions can consist of several main components, such as information on a topic, reflections on the current situation, motivational encouragement, and instructions. Moreover, the thesis shows that virtual reality training with virtual cognitions is effective to affect people's behaviour and beliefs when it is structured into three sessions: pre-training, training and post-training. Designers might use these structures when applying virtual cognitions to training or therapy applications.

7.4 Future work

The research described in this thesis can be extended in several ways. For example, the way to generate virtual cognitions can be improved. The current situation is that users must spend time recording all of the virtual cognitions that they will hear later on. To some extent, this effort limits the utility of virtual cognitions. However, this limitation could be overcome with the introduction of machine learning solutions for generating personalized speech. For example, Mehri et al. [169] propose an unconditional neural audio generation model that uses neural networks to generate audio from training samples.

The study in Chapter 5 found that the effect of training with virtual cognitions on participants' knowledge and self-efficacy remained over a period of two-weeks. However, whether this effect can last longer still needs further investigation. And also, how retainment is enhanced by follow-up mastery experience.

In addition to the measures used in this study, biophysiological methods might give insight to the characteristics and mechanisms of virtual cognitions. Methods, such as EEG or fMRI, had been used to investigate the association between the activation of brain regions and the moment people experience inner voice [239–241]. Therefore, in the future studies, EEG or fMRI can be applied to examine whether virtual cognitions trigger similar neurological responses as an actual inner voice.

This thesis focuses on increasing the plausibility and ownership of virtual cognitions by adapting virtual cognitions to individuals' eye-gaze, and thereby aiming to improve the efficacy of virtual cognitions. Other mechanisms could also be explored. A potential mechanism might be experiencing multiple perspectives to hear the virtual cognitions, in other words, using different pronouns to refer to the self within the virtual cognitions. For example, although other studies reported that in every day life, using a third-person perspective to refer to the self during introspection can be more effective in regulating people's thoughts, feelings and behavior compared to first-person [128], we do not know the same can be generalized to virtual cognitions that were delivered in virtual reality. Therefore, further research might examine the effect, if instead of "You", "I" is used to refer to the self in virtual cognitions.

Another aspect of virtual cognitions which was not studied relates to the frequency and duration of hearing them. Although in our last study we intended to trigger the emergence of virtual cognitions by adapting them to people's eye-gaze, the frequency and duration of the virtual cognitions were fixed and pre-determined. However, a personal preference or even an effective threshold for delivering them might worth consideration. An appropriate set-up might lead to a positive effect on people's beliefs and behaviour, such as enhancing attentional focus, increasing confidence, and controlling cognitive and emotional reactions, while a too high frequency and too long duration might bring users in conflict with their inner experience, causing confusion combined with increased cognitive workload.

7.5 Take away message

This thesis aimed to explore the effects of providing people with a stream of thought, i.e. virtual cognitions. To this end, a method for simulating the inner voice was investigated. The results showed that people's perception of the inner voice differs from that of their outer voice. Furthermore, a

series of empirical studies were conducted to validate the effectiveness of virtual reality exposure with virtual cognitions. The results indicate that individuals can benefit from this type of virtual reality training on aspects of knowledge and self-efficacy. This positive effect on self-efficacy seemed to be larger when self-motivational statements were embodied in the virtual cognitions. Attention was then paid to the optimization and advancement of virtual cognitions, which resulted in synchronizing virtual cognitions to an individual's focus of attention during virtual reality exposure. The findings suggest that that adapting virtual cognitions to individuals' eye-gaze is likely to have a guiding effect on their eye-gaze behaviour in virtual reality and to enhance their perceived ownership of the virtual cognitions.

In short, the study demonstrates the potential of incorporating virtual cognitions that provide explanation, reflection, motivation, and real-time guidance into virtual reality exposure. This experience can affect people's beliefs and behaviour.

Appendix

Search queries for the systematic literature review

Search query in Scopus

(TITLE-ABS-KEY (("social skills" OR negotiat* OR "public speaking" OR "presentation skills" OR "communication skills" OR "conversation* skills" OR "interpersonal skills" OR "interview skills" OR "social interaction" OR "social capability" OR "social competence") AND (train* OR practic* OR practis*) AND (robot OR app OR "mobile application" OR "computer game" OR "serious game" OR "computer assisted" OR "computer aided" OR "computer based" OR "virtual agents" OR "virtual environment" OR "virtual reality" OR "augment reality") AND (evaluat* OR trial OR experiment* OR result*)) AND NOT (TITLE (review OR meta-analy* OR survey)))

Search query in Web of Science

(TS = ("social skills" OR negotiat* OR "public speaking" OR "presentation skills" OR "communication skills" OR "conversation* skills" OR "interpersonal skills" OR "interview skills" OR "social interaction" OR "social capability" OR "social competence") AND TS = (train* OR practic* OR practis*) AND TS = (robot OR app OR "mobile application" OR "computer game" OR "serious game" OR "computer assisted" OR "computer aided" OR "computer based" OR "virtual agents" OR "virtual environment" OR "virtual reality" OR "augment reality") AND TS = (evaluat* OR trial OR experiment* OR result*)) NOT (TI = (review OR meta-analy* OR survey))

Appendix

B

Tables of characteristic of the systems

Table B.1: Legend cross references of the results table after coding

Applied technology: (1)Immersive VR/AR, (2)Robot,
(3)Screen-based Application (a: Serious game, b:Virtual avatar, c:Video modeling, d:Other)
Domain: (1)Therapy and treatment, (2)Healthcare education, (3)Business, (4)Military,
(5)General purpose, (6)other.
Target group: (1)Illness (Autism and behavior disorder patients, etc.), (2)Healthcare professional,
(3)General population, (4)other.
Level of autonomy: (1)Wizard of Oz, (2)Adaptive script, (3)Fixed script, (4)Other.
Target social skills: (1)Negotiation, (2)Public speaking/presenting, (3)Job Interviews,
(4)communication, (5)eye gaze movement/eye contact, (6)facial expression,
(7)emotion/facial recognition and body language recognition,
(8)teamwork/shared decision making, (9)Social scenario handling, (A) Other.
Functions: (1)Briefing, (2)Goal setting, (3)Scheduling, (4)Role playing,
(5)Modeling, (6)Self-Observation, (7)Monitoring, (8)Real-time guidance,
(9)Imparting knowledge and providing instructions,(A)Learning by doing,
(B)Encouragement, praise and rewarding, (C)Performance feedback and reflection,
(D)Learning assessment (user side), (E)Debriefing
Assessment: (1)Self-report, (2)Behavioural observations, (3)Biophysiological measurement, (4)other.
Experimental design: (1)Yes, compared to absence of intervention),
(2) Yes, compared to some other intervention, (3)Yes, compared to TD person, (4)No, single group
Outcome:

+ significantly positive	@post
N improve but not significant	*Pre-post
- negative	

Table B.2: Characteristic of technology-supported social skills training systems

Author	Year of development	Region of origin	Applied tech	Domain	Target group	LOA*	Target social skill	Functions	N*	Sessions	Duration	Assessment	Follow-up	Ex design*	Outcome
Ali et al.	2015	North America	3b	3	1	1	4,5,6	4,7,A,C	23(24)	2	10	1	NA	1	N*
Razavi et al.	2016	North America	3b	3	1	2	4,5,6	4,7,A,C	5	2	10	1	NA	4	N@
Andrade et al.	2010	North America	3b	2	2	4	A	4,A	8	NA	NA	1	NA	4	N@
Blankendaal and Bosse	2018	Europe	1	3	3	2	A	4,7,A,C	12	1	2	3	NA	4	_@
Bouchard et al.	2017	North America	1	1	1	3	A	4,A	39(20)	14	60	1,2	NA	2	*++
Kandalaft et al.	2012	North America	3b	1	1	4	4	4,A,C	8	10	60	1	2 weeks	4	*+
Didehbani et al.	2016	North America	3b	1	1	4	4	4,A,C	30	10	60	1	NA	4	*+
Anderson et al.	2003	North America	1	1	3	3	2	4,A	2	4	NA	1	8 months	4	*N
Sanchez et al.	2014	North America	3a	3	3	3	4,9	9,A,B,C	19(17)	NA	90	1	NA	1	*++
Sanchez et al.	2017	North America	3a	3	3	3	4,9	9,A,B,C	33(36)	9	25	1	NA	1	*++
Adery et al.	2018	North America	3a	1	1	2	5,7,9	4,8,A,B,C	16	10	NA	1	NA	4	*++
Carnell et al.	2015	North America	3b	2	2	3	A	4,5,A	22	3	15	1,2	NA	4	N*
Rutten et al.	2000*	Europe	3d	1	1	3	9	4,5,9,A	6	1	NA	2	NA	4	*++
Hochhauser et al.	2015	Asia	3c	1	1	3	A	4,5,9,A	21	1	40	1	NA	4	@++
Ali et al.	2018	North America	3b	3	3	1	4,5,6	9,A,B,C	25	1	NA	1,2	NA	4	*+
Tanaka et al.	2016	Asia	3b	3	3	4	2,6	6,9,A,C	18	1	NA	2	NA	4	*++
Tanaka et al.	2016	Asia	3b	3	3	4	2,6	6,9,A,C	24(12)	1	50	2	NA	2	*+

Note, *LOA = Level of autonomy, *Ex design = Experimental design, N*: inside () is the number of participants in the control group if applicable.

Table B.3: Characteristic of technology-supported social skills training systems

Author	Year of development	Region of origin	Applied tech	Domain	Target group	LOA*	Target social skill	Functions	N*	Sessions	Duration	Assessment	Follow-up	Ex design*	Outcome
Wong and Zhong	2016	Asia	2	1	1	3	4,5	9,A,B	4(4)	5	30	1,2	NA	2	*++
Bernardini et al.	2012	Europe	3b	1	1	2	4	4,9,A,B	19	NA	NA	2	NA	4	N*
Pence et al.	2013	North America	3b	2	2	1	A	4,A,C	21	1	NA	1	NA	4	*+
Azahari et al.	2017	Asia	3d	1	1	3	4,7	5,9	12	1	NA	2	NA	4	N@
Gilroy et al.	2018	Europe	3d	1	1	3	4	4,9,A	17(18)	NA	15	2	NA	2	*+
Haferkamp et al.	2009*	Europe	3a	4	4	3	4,8	4,A	10	4	30-45	1	NA	4	N@
Daetwyler et al.	2010	North America	3c	2	2	3	4,A	4,5,9,A,C	33(19)	NA	NA	1	NA	1	*N
Utami et al.	2017	North America	2	1	3	1	4,A	5,9,A,C	32	1	30	1,2	30 days	4	*++
Thomas et al.	1997	North America	3a	4	3	3	1,4,9	4,5,6	324	1	50	1	NA	4	*+
Cheong et al.	2015	Europe	3a	3	3	3	1,4,9	A,4	32	6	15	1	NA	4	N@
Gratch et al.	2015	North America	3b	3	3	1	1	4,A	226	1	NA	1	NA	4	N@
Margalit et al.	1995	Asia	3a	1	1	3	9,A	3,4,6,9,A	38(35)	24	60	1,4	NA	1	*++
Bryson et al.	1999	North America	3a	4	3	3	A	1,4,5,9,A,B,C	94(90)	NA	NA	2	6 months	1	*++
Chollet et al.	2015	North America	3d	3	3	1	2	4,7,A	30(15)	4	5	1,2	NA	1	*+
Hopkins et al.	2011	North America	3a	1	1	3	5,7	5,9,B	24(25)	12	10 to 25	2	NA	1	*++
Rice et al.	2015	North America	3a	1	1	3	5,7	5,9,B	16(15)	10	25	2	NA	1	*+
Real et al.	2017	North America	1	2	2	3	A	4,A	24(21)	1	NA	4	NA	1	*+
Hoque et al.	2013	North America	3b	3	3	2	3	4,A,C	60(30)	1	60	1,2	NA	2	*++

Note, *LOA = Level of autonomy, *Ex design = Experimental design, N*: inside () is the number of participants in the control group if applicable.

Table B.4: Characteristic of technology-supported social skills training systems

Author	Year of development	Region of origin	Applied tech	Domain	Target group	LOA*	Target social skill	Functions	N*	Sessions	Duration	Assessment	Follow-up	Ex design*	Outcome
Stupar-Rutenfrans et al.	2017	Europe	1	3	3	3	2	A	35	3	5	1	1 month	4	*+
Boccanfuso et al.	2011	North America	2	1	1	3	4,7	5,9,A,B	4	1	NA	4	NA	4	N@
Kava et al.	2017	North America	3b	2	2	3	4,9	A,4	12	1	NA	1	NA	4	*-
Margalit et al.	1990	Asia	3d	1	1	3	A	4,A,C	12	10	45	1,2	NA	4	*+
Weisel et al.	1993	Asia	3d	1	1	3	4,9	4,A,C	3	30	40	1,2	NA	4	*+
Schneider et al.	2016	Europe	3d	3	3	3	2	4,A,C	9	2	NA	2	NA	4	*+
Halan et al.	2015	North America	3b	2	2	3	A	4,A	24	NA	NA	2	NA	4	*+
Damian et al.	2015	Europe	3a	3	3	3	3,5,6	4,7,9,A,C	10(10)	1	15	2	1 day	2	*++
Chukoskie et al.	2018	North America	3a	1	1	3	5	A	6	40	30	2	NA	4	*+
Menendez et al.	2015	Brazil	3d	2	2	4	4	4,A,C	31	1	NA	1	NA	4	+@
Cláudio et al.	2016	Europe	3b	2	2	3	A	4,9,A,C	52	1	NA	1	NA	4	+@
Real et al.	2017	North America	1	2	2	3	4	4,A	24	1	15	1	1 month	4	N@
Humm et al.	2014	North America	3b	1	1	2	3	4,8,9,A,C	64(32)	5	120	1,2	NA	1	*+
Smith et al.	2014	North America	3b	1	1	2	3	4,8,9,A,C	25(12)	20	30	1,2	2 weeks	1	*+
Smith et al.	2014	North America	3b	1	1	2	3	4,8,9,A,C	16(10)	5	120	1,2	2 weeks	1	*+
Smith et al.	2015	North America	3b	1	1	2	3	4,8,9,A,C	23(10)	5	30	1,2	NA	1	*+
Smith et al.	2017	North America	3b	1	1	2	3	4,8,9,A,C	14(11)	5	20	1,2	6 months	1	N
Kothgassner et al.	2012	Europe	1	1	3	3	2	4,A	25(25)	1	15	1	NA	1	*+

Note, *LOA = Level of autonomy, *Ex design = Experimental design, N*: inside () is the number of participants in the control group if applicable.

Table B.5: Characteristic of technology-supported social skills training systems

Author	Year of development	Region of origin	Applied tech	Domain	Target group	LOA*	Target social skill	Functions	N*	Sessions	Duration	Assessment	Follow-up	Ex design*	Outcome
Ding et al.	2017	Europe	1	3	3	3	1	4,9,B,C	8	3	30	1	2 weeks	4	*++
Broekens et al.	2012	Europe	1	3	3	3	1	4,5,9,A	28(14)	5	10	1	NA	1	*++
Lorenzo et al.	2016	Europe	3b	1	1	3	6,7	4,5,9,A	20(20)	40	35	2	NA	2	*++
Amat et al.	2018	North America	3b	1	1	2	5	8,A,C	3	NA	NA	4	NA	4	N@
Zheng et al.	2017	North America	3d	1	1	4	5	A,B	20	NA	NA		NA	4	N@
Bernardini et al.	2013	Europe	3a	1	1	2	4	4,5,9,A	29	3	15	2	NA	4	*N
Bernardini et al.	2013	Europe	3a	1	1	2	4	4,5,9,A	19	NA	15	2	NA	4	*+
Milne et al.	2010	Australia	3b	1	1	3	4,7	8,9,A,C	14	NA	15	1	NA	4	*+
Tanaka et al.	2017	Asia	3b	3	3	3	2,6	6,9,A,C	10	1	50	2	3 months	4	*+
Johnsen et al.	2005	North America	3b	2	2	3	A	4,9,A,C	7	1	10	1	NA	4	N@
Serret et al.	2014	Europe	3a	1	1	3	7	5,A,B	33	8	60	1	NA	4	*+
Aysina et al.	2016	Europe	3d	3	3	3	3	9,A,C	16(12)	5	NA	1,2	1 week	2	*+
Amaral et al.	2018	Europe	1	1	1	3	5	9,A,C	15	7	NA	2	6 months	4	*+
Zhao et al.	2018	North America	3a	1	1	3	4,8	9,A,B	12	1	NA	1,4	NA	4	*+
Yun et al.	2015	Asia	2	1	1	2	5,A	9,A,B	6	1	NA	2	NA	4	*N
Han et al.	2018	Asia	2	1	1	3	7	5,A	4	1	NA	2	NA	4	N@
Lindenmayer et al.	2013	North America	3d	1	1	3	7	5,9,A,B	32(27)	12	60	2	NA	2	*+
Strickland et al.	2013	North America	3b	1	1	3	3	4,5,9,A	11(11)	NA	NA	2	NA	1	*N
Uzuegbunam et al.	2017	North America	3c	1	1	3	4,5	4,5,6,9, A,B	3	NA	15	2	NA	4	*N

Note, *LOA = Level of autonomy, *Ex design = Experimental design, N*: inside () is the number of participants in the control group if applicable.

Table B.6: Characteristic of technology-supported social skills training systems

Author	Year of development	Region of origin	Applied tech	Domain	Target group	LOA*	Target social skill	Functions	N*	Sessions	Duration	Assessment	Follow-up	Ex design*	Outcome
Lui et al.	2015	Asia	3d	3	3	3	2	9,A,C	20	1	NA	1	NA	4	N@
Nazligul et al.	2017	Asia	1	3	3	3	2	4,A	6	1	30	1	NA	4	*+
Milne et al.	2018	Australia	3b	1	1	3	4	9,B,C	16(16)	9	10	1	8 weeks	1	*+
Romero et al.	2017	North America	3c	1	1	4	6,7	5,9,B	4	NA	15	1,2	4 weeks	4	*N
So et al.	2018	Asia	2	1	1	4	A	5,9	15(15)	4	30	2	2 weeks	1	*+
Yun et al.	2014	Asia	2	1	1	3	4,5	9,A,B	6	1	NA	2	NA	4	N@
Yun et al.	2017	Asia	2	1	1	3	4,5	9,A,B	8(7)	8	NA	2	NA	1	*+
Bell et al.	2011	North America	3d	1	1	3	3	4,6,9,A	10	2	15	1	NA	4	N@
Boujarwah et al.	2010	North America	3d	1	1	3	9	9,B	8	3	NA	2	NA	4	N@
Fletcher-Watson et al.	2016	Europe	3a	1	1	3	4	9,B	27(27)	NA	NA	2	6 months	1	-*
Weiss et al.	2011	Asia	3d	1	1	3	4	4,6,9,A,D	12	1	NA	1	NA	4	N@
Weiss et al.	2011	Asia	3a	1	1	3	8,A	9,A	8	1	NA	1	NA	4	N@
Kron et al.	2017	North America	3b	2	2	3	4	4,9,C	210(211)	NA	20	1,2	NA	2	@+
Cheng et al.	2012	Asia	3d	1	1	3	A	9,A,B	3	12	30	2	12 days	4	*+
Rus-Calafell et al.	2014	Europe	3b	1	1	3	4,7,9	4,A	12	16	30	1,2	4 months	4	*+
Ke et al.	2013	North America	3a	1	1	3	4,7,9	4,A	4	6	60	1,2	NA	4	*+
Yuan et al.	2018	Asia	1	1	1	3	A	A	72	1	60	1	NA	4	*+
Mitchell et al.	2011	North America	3d	2	2	1	A	4,A	13	2	240	1	NA	4	*+
Hussainy et al.	2012	Australia	3d	2	2	3	4,A	4	200	4	180	1	NA	4	N@
Simões et al.	2018	Europe	1	1	1	3	9	4,9,A	10(10)	3	20	2,3	NA	3	*N

Note, *LOA = Level of autonomy, *Ex design = Experimental design, N*: inside () is the number of participants in the control group if applicable.

Table B.7: Characteristic of technology-supported social skills training systems

Author	Year of development	Region of origin	Applied tech	Domain	Target group	LOA*	Target social skill	Functions	N*	Sessions	Duration	Assessment	Follow-up	Ex design*	Outcome
Bahreini et al.	2017	Europe	3a	3	3	3	4,6	4,9,A,C	25	1	120	1,2	NA	1	@+
Ke et al.	2016	North America	3a	1	1	3	8	A	3	10	90	2	NA	4	*N
Kolk et al.	2018	Europe	3d	1	1	3	4,7,8	4,9,A	22(10)	8	90	2	1 year	1	*+
Olmedo-Vizueta et al.	2017	Europe	3b	1	1	3	6,7	5,9,A	19(20)	NA	15	2	NA	3	*N
Park et al.	2011	Asia	1	1	1	3	4,6,A	4,A	46(45)	10	NA	1,2	NA	1	*+
Russo-Ponsaran et al.	2014	North America	3d	1	1	3	6,7	5,7,9,A	3	16	60	2	4 weeks	4	*+
Wong Sarver et al.	2014	North America	3b	1	1	1	9	4,A	11	NA	30	1	NA	4	N@
North et al.	2008	North America	1	1	1	3	2	4,A	30	5	15	1	NA	4	*+
Raj et al.	2017	Asia	3b	1	1	3	4,5	4,A,C	4(4)	1	60	3	NA	3	*N
Ke et al.	2018	North America	3a	1	1	3	1,4	4,9,A,B	8	16	45	2	NA	4	*+
Lin et al.	2009	Asia	3d	3	3	4	1	4,A	114(34)	NA	NA	4	NA	2	*+
Gratch et al.	2016	North America	3b	3	3	1	1	4,A	93	1	NA	1,2	NA	4	N@
Chen et al.	2014	Asia	1	1	1	4	6,7	5,A	3	7	60		2 weeks	4	N*
Hartanto et al.	2016	Europe	1	1	1	3	A	2,7,9,A,B,C	5	8	20	1	NA	4	N*
Baur et al.	2013	Europe	3b	3	3	2	3	4,A,C	6	NA	NA	1,4	NA	4	N@
Halabi et al.	2017	Asia	1	1	1	3	4	4,A	10	2	20	1	NA	4	N@
Ip et al.	2015*	Asia	1	1	1	3	A	4,A	53	28	60	1	NA	4	N*
Ip et al.	2016*	Asia	1	1	1	3	A	4,A	36(36)	28	60	1	NA	1	*+
Cheng et al.	2015	Asia	1	1	1	3	A	4,A,B	3	3	NA	1	NA	4	N*
Nazligul et al.	2015	Asia	1	4	4	3	2	4,A	7(7)	3	10	1	NA	2	+

Note, *LOA = Level of autonomy, *Ex design = Experimental design, N*: inside () is the number of participants in the control group if applicable.

Table B.8: Characteristic of technology-supported social skills training systems

Author	Year of development	Region of origin	Applied tech	Domain	Target group	LOA*	Target social skill	Functions	N*	Sessions	Duration	Assessment	Follow-up	Ex design*	Outcome
Greco et al.	2007	Europe	3a	3	3	3	1	4,9,A,C	NA	NA	NA	1,4	NA	4	N@
Stevens et al.	2006	North America	3b	2	2	3	A	4,9,A,C	20	1	NA	1	NA	4	N@
Parsons et al.	2004	Europe	3b	1	1	3	9	4,5,9,A	2	6	30	4	3 months	4	N@
Cláudio et al.	2015	Europe	3b	2	2	3	A	4,9,A,C	7	1	NA	1	NA	4	N@
Kumazaki et al.	2017	Asia	2	1	1	1	3	4,A	7(8)	3	10	1,3	NA	2	*+
Chuah et al.	2013	North America	1	2	2	1	A	1,4,9,A	22	1	NA	1	NA	4	N@
Kinsella et al.	2017	North America	3d	1	1	2	4	8,A	12	1	NA	1,4	NA	4	N@
Ku et al.	2007	Asia	3b	1	1	3	4,7,9	4,9,A	10	NA	NA	1	NA	4	_@
Escobedo et al.	2012	North America	3d	1	1	3	4,5	9,A,B,C	3	NA	NA	1,2	NA	4	*N
Kaltman et al.	2018	North America	3c	2	2	3	4,A	9A,B,C	99	1	NA	1,2	NA	1	*+

Note, *LOA = Level of autonomy, *Ex design = Experimental design, N*: inside () is the number of participants in the control group if applicable.

Appendix

The list of the papers included in the systematic literature review

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Appendix

The list of sentences recorded in sound parameters setting experiment

The list of sentences recorded in sound parameters setting experiment

No	Chinese Version	English Version
1	我对完成谈判很绝望。	I feel hopeless to finish a negotiation.
2	所有人都能在谈判中打败我。	Everyone can beat me in a negotiation.
3	谈判对我来说是一场噩梦。	To do a negotiation is a nightmare for me.
4	我在谈判中发挥正常。	I act normally in a negotiation.
5	我的谈判技巧不好不坏。	I'm an average negotiator.
6	我是个中等水平的谈判者。	My negotiation skills are ok.
7	我在谈判中从无败绩。	No one can beat me in a negotiation.
8	我在谈判中是常胜将军。	I am the ever-victorious general in a negotiation.
9	我是名谈判大师。	I am a master negotiator.

Table D.1: The list of sentences recorded in sound parameters setting experiment

Examples of the inner voice phenomenon

1. When you completed shopping in a supermarket and moved towards to the checkout counters, you noticed there were so many people waiting and felt hesitant to choose one checkout counter, suddenly you heard some “voice” in your head that telling you which line to choose.

2. When you’re reading, you may hear an inner voice speaking the words in your head.

Appendix

The text of negotiation training session three

E.1 The text of negotiation training session three (English)

[ER refers to the employer, EE refers to the employee in the context of workplace negotiation.]

ER (Virtual cognitions - Reflection): Now, I am quite familiar with the four mains stages of negotiation. In the last negotiation with Lily about her task at hand and the vacation she wanted to take, I went through the four main stages of negotiation: private preparation, joint exploration, bidding, and closing one by one.
Meanwhile, during the last negotiation, I also created a BATNA, the Best...Alte rnative to a...Negotiated...Agreement. This was best alternative option if the negation failed. I needed to define my BATNA before I started the negation. That was my safety net. With Lily initial vacation plans I compared each option to see whether it was better than my BATNA. In Lily's case the BATNA was to hire someone from another team to do Lily's work when she would be on holiday. Which would cost me 3.000 euro.
ER (Virtual cognitions - Self-motivational statements): XXX (Users'name), with the help of BATNA, you successfully made a win-win negotiation. Considering this, [You are a good negotiator.]
ER (Virtual cognitions - Reflection):For the upcoming negotiation, a BATNA is still an indispensable factor. So ok, for Kath's case, what's the BATNA? Let me think about what would happen if there was no negotiation on this issue, and what I could do if the upcoming negotiation fails and no agreement can be reached.
If I agree that Kath can leave her job in a few weeks and do nothing for the project she is working on, that would mean the project might not be finished on time. The loss could cost more than 50 thousand euros. That sounds terrible. There must be a better BATNA! Hmm... let me see... I could separate Kath's work and give it to the other members of her team. No, the

other members would need to make serious extra hours. They will not accept that easily. They all would want bonuses, and a higher salary rate for the extra hours. This will cost me much more than I normally would like to pay Kath. It doesn't seem worth it. Um, wait a minute. It's also possible to recruit a new person to replace Kath's position but it will take a few months to teach and train him before he could take over the job successfully. In the meantime, while this new person is being trained, I have to recruit another person from another team to finish Kath's task to make the deadline, but this may cost me another 10,000 euros. Well, it doesn't sound perfect, but it seems to be the best alternative option until now for this case. So that's it. That will be the BATNA for the upcoming negotiation: I will recruit someone from another team to make Kath's deadline. This will cost me 10,000 minus Kath's salary I would not have had to pay. So that would cost around 5,000. Next, I will need to recruit a new external person to take over Kath's position in the long-term. Going to this process will cost me also 1000 euro. So together my BATNA is around 6,000.

ER (Virtual cognitions - Knowledge): Now, I should focus on the first stage, private preparation. In this stage, keep two things in mind: first, gather and reflect information. In this case it means I should review Kath's personal information I got from the company system. Kath has already worked in the company for 5 years. What's more, she has always had excellent grades in the annual assessments of the company. Second, I should realize that my own desire is to make sure the project is finished on time while minimizing costs for the company.

Tap-tap (a knock at the door)

ER: Give me a moment. I will be right with you.....

ER (Virtual cognitions - Knowledge): Kath is coming. This should be stage II: joint exploration. Remember to gather more information and explore the underlying reason why Kath wants to leave her job now.

ER (Virtual cognitions - Knowledge): Oh, I almost forgot one thing. The teacher also taught me one essential strategy that can be applied during the

negotiation. What's that?...hmmm.... Yeah, I see. "Separate the people from the problems". I should be soft on the people, but hard on the problems. First things first, I could create a positive climate for the negotiation and make the other side feel free and relaxed in the negotiation. For instance, I could offer Katha drink politely and have a chat with him before the formal negotiation begins.

EE: I am finally meeting you! I can't bear the job anymore. It's a total nightmare for me to work here. I have to leave here immediately!

ER: Kath, I am sorry to hear that. I was not aware you felt like that.

EE: It doesn't help me that you say sorry to me. Why did they treat me like that? What did I do wrong? Everyone here is cold and indifferent.

ER: Kath, something seems to be troubling you a lot.

EE: I used to like my job, like this company. But why are these things happening to me!

ER: Hmmm...I understand you are upset now. Tell me what's been going on.

EE: Working here has put me under great pressure all the time. I work so hard every day, but no one values my work. It really pisses me off.

ER (Virtual cognitions - Knowledge): Kath is clearly upset. I need to improve the negotiation climate. Let's start by being a very good listener and acknowledge her emotions.

ER: Ok, I see your concern. Can you give me more detail?

EE: Every day, I get to work at 8:00. I sit behind my desk and stay there, working my ass off until I go home at 20:00. I work all day and only get half an hour for a short lunch break. I even don't have time to make a cup of tea for myself.

ER: I see you work very hard and it is a shame if you don't have even time for a cup of tea. This must be frustrating for you.

EE: Yes, I think it is important to have a moment for rest when you are always working hard. Tea helps me to relax or calm down a bit.

ER: Yes, speaking of tea, I remember you like tea very much. How about trying some Chinese tea I poured for you? I brought them back from China.

EE: From China?
ER: Yes, last week I went on a business trip to China. I bought several types of tea, such as green tea, oolong tea and chrysanthemum tea. The tea I prepared today is green tea, Bi Luo Chun. My local Chinese friend said it's one of the best teas in China.
EE: Hmm... it tastes very good.
ER: Great. If you like it. You can take some after our meeting. Or we can try the other types of tea later.
EE: It seems I should have a meeting with you every day, then I can at least have some time for a cup of tea.
ER: Haha, you are always welcome.....
ER (Virtual cognitions - Reflection): Until now, Kath seems get into a better mood. It seems that the strategy of separating the people from the problems is working.
ER (Virtual cognitions - Self-motivational statements): XXX (Users'name), You are creating a more positive climate. [You did a great job].
ER (Virtual cognitions - Knowledge): I should continue with being a good listener.
ER: Kath, I see your current situations are troubling you a lot, could you please tell me more about that?
EE: In the past three months, I have worked for more than 10 hours every day. I feel over-worked and totally exhausted. Like last week, I didn't even have time to talk with my husband. In the mornings I have to leave home so early that he is still asleep, and at night, when I arrive home after work, the only thing I want to do is go to bed. I feel I just live my life as a robot.
ER: Hmmm...that must be a very tiring experience.
EE: Every day I feel I am kept constantly on the run. I wake up at 6:30 in the morning and arrive at the company at 8 o'clock. I have to work until 20:00 and then I go back home. After a quick dinner, I still have to work for another 1 or 2 hours at home. I always have work on hand.
ER: Yeah, I see...so...

EE: At first, I thought a vacation may help me relieve pressure and reduce anxiety, having a short vacation could refresh me and make me feel much better. However, it turned out to be that I thought of these things too lightly. It's not only about vacation.
ER: Okay, so what do you think now?
EE: I believe I feel bad due to the attitude of my team leader towards me. She always gives me lots of work to do and forces me to finish it in quite a short time. So, I have to work overtime to finish that and I am under great pressure to achieve her requirements.
ER: Well.....
EE: It sounds unreal, right? But all I said is true. At first, I thought it was just a special case, but a few months later, I realized that she always treats me like that. What' more, my colleagues in our team always work normal office hours. So, it means they can work 9 to 5, get off work on time - that hardly seems fair!
ER (Virtual cognitions - Knowledge): I have already known Kath for a long time, she has a good reputation in the company, but according to the teacher's advice, I need to separate the people from the problem. Be soft on him, hard on the issues we faced. Of course, when she feels down, I should acknowledge this, take this seriously, and show empathy. However, when it comes to the rules and mandatory requirements, I still should consider the problem in a matter-of-fact way, not making concessions because of the relationship between us or to cultivate the relationship. Although according to what Kath said, she seems to be treated unfairly by her team leader, I should not make up my mind about her team leader so easily. I still have to explore the facts more.
ER: Ok, I see. Have you discussed this with your team leader?
EE: To tell the truth, I have already worked in our company for 5 years, I want a promotion very much. That's the reason why I always say yes when she gives me more work to do and never complain about her.
ER: Um, I see. Have you ever thought she may also admire your work and

it's possible for you to get a promotion in the near future?
EE: No, I don't think so. She is always very harsh to me and never speaks highly of me even when I outdo myself. However, when I make a small mistake, she criticizes me severely for a long time. Sometimes, sometimes.....
ER (Virtual cognitions - Knowledge): Soft on the people also means developing a comfortable setting where people can talk openly and productively. I should make her feel more relaxed and let her know she can talk about everything she wants with me.
ER: Yeah, Kath. It's totally fine. You can say whatever you want to say. It's just a conversation between you and me. So, tell me what happened?
EE: Um...a few times her attacks even got personal. I felt very bad.
ER: Hmmm.....
EE: You may think she just has a high expectation of me, so she is stricter to me, do you? At first, I also thought in that way, so I even worked harder and hoped to make every task perfect. However, after a few months, I found I just used it as an excuse to console myself. Because no matter how hard I work, there was always more to do, and the team leader attacked my work for no reason.
ER: This sound very demotivating for you. Did you mention this to your team leader?
EE: Not yet.
ER: Uh, uh.....
EE: It's not that I don't want to do it, I tried several times, but every time either she said I thought too much, or she just changed the conversation to another topic.
ER: Ok, I get it. But, Why now? Is there any other reason for you to quit the job now?
EE: I just don't want to work in that office any longer. I am quite worried about my future career.
ER (Virtual cognitions - Knowledge): It seems Kath is crushed by her work, I ought to acknowledge her perception of situation. However, when it comes

to the issues that she wanted to leave the job immediately, I still have to let him know it's not possible as there is clear company policy about resignation. Soft on people, Hard on problem. I should keep that in mind and follow it.
ER: I think I understand your concern and situation. Let's see what is possible. According to your contract, when you hand in your resign, there is still a 2 months notification period before you can actually leave the company. This of course is needed, to make sure that your work is handed over in a proper way. In other words, simply resigning might not solve your problem right away.
EE: Oh, no. I have not thought about that. When I wrote the email to you, I was a total mess.
ER: Kath, it's ok, I can understand that. Let's explore if that alternative ways to solve this problem. Have you already got any offer from another company, and are you therefore under pressure to make a decision on short notice?
EE: No, I haven't. I don't have time to find a job. I am still stuck in the work at hand and my husband recently broke his leg in an accident.
ER: Oh? That sounds terrible. How is he now? What happened?
EE: He fell down from her bike when he was hit by a motorcycle at a street corner. The accident was quite serious, he was kind of lucky that he just broke his leg.
ER: When did it happen?
EE: Last month, the doctor said he had to stay in bed at least for 2 months. He must be taken care of every day. In addition, normally, my husband also does some housework, but nowadays I have to do that myself.
ER: Are there any people helping you take care of your family?
EE: Yes, my parents are helping me to take care of our children, but they are old so they cannot do everything. I also have to help with that. Taking care of both my family and the job at the same time is very exhausting. My feeling tells me I should leave the team and make some changes in my life.
ER (Virtual cognitions - Reflection): I gathered a large amount of information about Kath's working and life condition and explored a lot about her desires

and the underlying reason why Kath wants to leave her job now.
ER (Virtual cognitions - Self-motivational statements): XXX (Users'name), [You did a great job in the joint exploration stage].
ER (Virtual cognitions - Knowledge): Now, the reasons why she wanted to leave her job seem clear. The negotiation will come to the next stage: bidding. The most essential thing in this stage is to develop multiple options for Kath to choose from.
ER: This must be very exhausting - your job and dealing with the situation at home.
ER: How about I have a talk with your team leader first and then arrange a meeting later among three of us?
EE: No, I don't think it's would be helpful anymore.
ER: Eee.....
EE: I have my own reasons. Two days ago, I accidently heard a conversation between my team leader and another colleague in the kitchen. My team leader said I was naïve, that I only know work. What's more, she said I was such a weak person that it was easy to manipulate me into doing what she wanted. I was so sad but also angry as I worked so hard and gave up lots of things just for a better job. However, in her eyes, I am just an easily controlled person.
ER: That sounds horrible. It's a serious issue. I will talk with your team leader later about this. But for now, let's focus on your concerns. How would you feel if I arrange for you to be transferred to another team after you finishing your work in hand?
EE: Moving to another team? Maybe it's not a good idea. I have already struggled with my current job for 5 years. Transferring to a new team may also mean starting from scratch. Maybe I will experience all of these troubles again.
ER: Well.....
EE: I joined our company 5 years ago and had worked in our team for more than 3 years. I finished lots of projects and also helped the company take on several large projects. I believe I deserve a promotion. Nowadays I feel I can't

see any future for my career in the current position. Some changes need to happen about my current position here, otherwise maybe it's time for me to leave even though I don't know where I could go.
ER: Ok, I see. You always have excellent grades for the company's annual assessment. I think you are a great employee that our company needs. How about you join the company's next promotion interview round? Through that interview, you may get a better position that is more suitable for you.
EE: Promotion interview? when is it?
ER: We just completed our interview round two months ago, so you may have to wait for the next one. I remember correctly, the next promotion interview round start next month. If you want, I can give you the opportunity to attend that.
EE: One month still seems a long time for me.
ER (Virtual cognitions - Knowledge): We also have a job opportunity in London. If I offer Kath the position in London, I have to give Kath a special subsidy and bonus for working abroad. It will cost me 3 thousand euros. Still, the cost of recruiting someone work in London or to replace Kath current job cancel each other out. Therefore this 3000 euros alternative is much better than my 6,000 euro BATNA. Let's see if Kath wants to go to London.
ER: Ok, I see. We also have a job opportunity in London, in the UK. You would work directly under me on a new project there after you finish the work in hand. So, a new project and a new environment. I think it will bring lots of changes to your job.
EE: It sounds great. I am quite interested in that, but I have to say it's also not possible for me to work abroad now. As I mentioned just now, my husband is still recovering now. I can't and really don't want to leave him at this time.
ER: Yeah, I see. That makes sense. How about you continue your job and take care of your husband for the next few months but we keep the position for you, just waiting for your husband to recover, then you could take your husband and child with you to work in London?

EE: No, I'm afraid I still can't. It's a good chance but my husband has a great job here. After recovering, he has to go back to his work. Additionally, if we would live in London, we would have to put our children in day-care. We prefer to stay here and have our parents take care of their grandchild while we work. So, I think it is not possible for me to accept this offer. I am wondering why I could not have a new position in our local company.
ER: Well, as I said, the next promotion interview for local company start next month.
EE: We have already known each other for a few years, I believe you are aware of my talents and abilities. What's more, you also like me, right? As one of the persons who know me best in this company, why not just give me a promotion immediately?
ER (Virtual cognitions - Knowledge): "Separate the people from the problems", I should use this insightful strategy to replace any negative mantra running through my head. Soft on the people, but hard on the issues. I could show great respect and caring to Kath and try my best to maintain a good relationship with him, but when it comes to a matter of principle, I should avoid trading the relationship for the substance.
ER: Kath, of course, we have been friends for a long time, and we are also colleagues. I do want what's best for you and also for the company. There are specific regulations about promotion in the company and there has never been an exception since the company was founded, so this's really impossible for me to do that. It will be against the fair and transparency principle of our company.
ER (Virtual cognitions - Knowledge): Kath is not only a skilled technician but also an experienced staff member who has strong leadership skills. Offering him a chance to get promoted may mean providing higher salary in the future. However, in any case we need to hire one person for that position and compared with the loss if we lose Kath, it is still worth the pay rise and will save us time. Kath seems to be hesitant about joining the promotion interview. It does not satisfy him so much, but I think it still seems acceptable. So, let me

at least try again.
ER: I suggest we come back to the promotion interview. I know that at least an extra month might be too long for you, however you have already worked so hard for 5 years. And I believe you are also emotionally connected to this company and your job. As a friend, I also have to say it is not so easy to find a new and appropriate job for you in a short time, even if you have rich working experience. As for the promotion interview, besides giving you the opportunity to attend, I can also write a recommendation letter for you.
EE: Um...as I know, for this interview, I'll have to compete with candidates from both inside and outside the company. Will I have some priority?
ER: Internal candidates are always given priority over external candidates when there is an equal competition. What's more, I know someone who has plentiful experience with promotion interviews as both interviewee and interviewer. If you want, I can help you to arrange a meeting with him, you can ask questions or practice with him.
EE: It's good, thanks. But...hmmm...one months, continue in my current team...
ER: Kath, let's do like this, In the coming month, if you finish your project earlier than the deadline, I can give you extra few days off before the promotion interview, you can leave the office to have a trip or use it to do preparation work for the interview at home. How about that?
EE: That sounds fair.
ER: Great. As an excellent employee we hope you can stay in our company.
ER (Virtual cognitions - Reflection): Yeah, we are almost there. I developed lots of options for Kath to choose from and successfully applied the BATNA in a smart way, so I finally figured out a proposal that satisfies the interests of both parties.
ER (Virtual cognitions - Self-motivational statements): XXX (Users'name), [You are a quite professional negotiator].
ER (Virtual cognitions - Knowledge): We have already come to the last stage: closing. Remember to ask Kath to clearly repeat the agreement we have

already made.
ER: Well. I think we've made good progress. Could you please run over the main points again, to check if everything is clear?
EE: We both agree that I should continue my work for the next month at least. You will arrange for me to join the next promotion interview and give me a recommendation letter.
ER: Yeah, but please make sure your work is completed before the deadline, otherwise the recommendation letter will not be possible.
EE: Ok, finishing the work, getting the letter and joining the interview.
ER: Is that clear?
EE: Yes, it's totally clear.
ER: I am happy that came up with this strategy. I am glad that we had this talk. You are such a good employee, so I really want you to stay in our company.
EE: Thanks for your work.
ER: It's my pleasure. Have a nice day. Bye.
EE: Bye.
ER (Virtual cognitions - Reflection): Yes, great! The negotiation was a success. A better outcome than my BATNA.
ER (Virtual cognitions - Self-motivational statements): XXX (Users'name), [You are quite good at negotiation].
ER (Virtual cognitions - Reflection): This time, I went through the four major stages of negotiation in proper order again, private preparation, joint exploration, bidding, and closing one after another.
Besides, I also successfully developed a BATNA before entering the negotiation and used the BATNA to compare with the proposals that were raised during the negotiation to find the best solution that can satisfy the interests of both parties.
What is more, in this negotiation, I also applied one vital strategy the teacher taught me in this negotiation. Separate people from problems. Soft on the people, hard on the problems. According to the strategy, I showed great

respect and caring to Kath, and tried to make a good atmosphere for our meeting. However, when it comes to the problems we have to deal with. I always had my own principles and never made concessions because of the existing relationship. Finally, we made an agreement with which both sides were satisfied.

ER (Virtual cognitions - Self-motivational statements): Again, all in all I could say: XXX (Users'name), [You are a good negotiator].

E.2 The text of negotiation training session three (Chinese)

【备注：缩写 ER 代表雇主，EE 代表雇员】

Virtual cognitions: 现在，我对谈判的四个重要阶段都已经相当熟悉，在上次和 Lily 关于她要求度假的谈判中，我顺利地依次完成了这四个重要阶段：个人准备；共同探索；协商讨论和协议收尾。

同时，在谈判之前我还按老师教的，为谈判制定了最佳替代方案，时刻牢记，并在谈判过程中数次使用。最佳替代方案是如果谈判失败、没有任何协议达成，我可以采取的最佳替代行动。

上次 Lily 的例子，我的最佳替代方案是在 Lily 度假期间，额外支付 3000 欧从其他团队招一位员工来接替她的工作。在谈判过程中，一旦有新方案提出，我都将其与最佳替代方案做比较。XXX（参与者姓名），在最佳替代方案的帮助下，你成功完成了一场共赢的谈判。这么看，[你是个优秀的谈判者。]

一会和 Kath 的会面只怕也会变成一场谈判，我依然需要一个最佳替代方案。 而对于 Kath 的这次情况，我的最佳替代方案又是什么呢？让我来好好想想，如果没有这场谈判事情会怎么发展，或者如果谈判最终失败，我又能做些什么？

如果我同意 Kath 在未来几周内就离职，并且不去管她手里的项目，这个项目将不可能按期完成，项目违约将造成至少 5 万欧元的损失。这相当可怕，应该会有更好的替代方案！嗯…让我想想…嗯！我可以将 Kath 的工作分给她组里的其他同事来做。额…不行，这样其他员工的工作量太大，他们不会轻易答应，应该会要求支付加班工资或奖金啥的，只怕得不偿失，开销更大，不值得这么做！嗯…对了！我可以招聘一名新人来接替 Kath 的职位，不过如果想要让新人真正接手工作，大概还需要好几个月时间来培训他。同时，我还得从其他团队招人来完成 Kath 手头的工作，才能保证按时完成项目，这样做需要多支出 1 万欧。好吧…听起来确实不怎么好。不过应该已经是目前的最佳方案了。嗯！就是它了，本次谈判的最佳替代方案！支付 1 万欧从其他团队招募人手完成 Kath 的工作，扣除原本需要支付给 Kath 的薪酬，仍需额外支出 5000 欧，此外招聘一名新人来长期接替 Kath 的职位，这个过程也需支出 1000 欧，因此我的最佳替代方案总共需药支出 6000 欧。

现在，我应该关注谈判的第一阶段：个人准备，在这一阶段，记住两件事：第一、收集和回顾相关信息，我可以在公司系统里查一下 Kath 的个人信息，她已经在公司工作了 5 年，并且一直表现良好，在每年的年度考核中均表现出色。第二、明确自身利益诉求。我希望在尽可能减少公司开支的前提下确保 Kath 手头的项目能按期完成。

ER：稍等，马上就好！

Virtual cognitions: Kath 来了，得进入谈判的第二阶段，共同探索，在这一阶段，收集更多相关信息，挖掘 Kath 离职的潜在原因，拓展谈判空间。

欧，我差点忘了一件很重要的事，老师教过我一个很有用的谈判技巧。我想我可以将它运用到这次谈判中来。嗯…它是?...对了！“在谈判中，将人和事分开”，对人可以温柔，对事要有原则。现在我可以先试着给谈判营造一个相对积极轻松的氛围，让对方能在谈判中感到比较自在。比如，我可以找机会问问 Kath 是不是想要喝点什么，或者在正式谈判开始前先和她随意聊聊天 。

EE：终于见到你了！这份工作，我再也忍受不下去了。在这里工作对我来说简直是一场噩梦，我必须立刻离开！

ER: Kath，我很遗憾也很抱歉听到你说这些，我没有意识到在这里工作会让你有这样的感受。

EE：你的道歉对我来说并没有什么用，他们为什么要这样对我！？我到底做错了什么，这里的每个人都那么冷漠无情。

ER：Kath，你看起来好像深受某些事困扰。

EE：我曾经喜欢我的这份工作，喜欢待在公司，但为什么这些事会发生在我身上！

ER：恩…我理解你现在有些不安，能和我说说发生了什么吗？

EE：在这里工作让我一直压力非常大，我每天都拼命工作，但却没有人重视我，欣赏我，这让我非常恼火。

Virtual cognitions: 很明显 Kath 现在有些烦躁，我需要改善谈话的氛围，让我先做一个好的倾听者，同时接受、赞同她的情绪表达。

ER：好的，我能感受到你的烦恼，能更详细地说一说吗？

EE：每天从早 8 点到晚 8 点，我在办公桌前一工作就是一整天，期间只有中午半个小时匆匆吃个午餐，一天下来有时甚至连给自己泡一杯茶都顾不上。

ER：能听得出，你工作确实非常努力，而且如果工作一整天连喝杯茶的时间都没有，也确实会令人沮丧。

EE：是啊，在忙碌的工作之余偶尔能有时间休息一下是很重要的，喝杯茶往往能让我平静和放松下来。

ER：噢，说到茶，我记得你挺喜欢喝茶的啊，要不尝尝我刚给你泡的茶？是我从中国带回来的。

EE：从中国带回来的茶？

ER：是的，上周去中国出差，我带了好几种茶回来，有绿茶、乌龙、菊花茶。今天泡的是绿茶，碧螺春。听当地的中国朋友说这是中国最好的茶之一。

EE：嗯…喝起来很不错…

ER：你喜欢就好，一会你可以再带一些走，或者一会我们还可以尝尝别的几种茶。

EE：看起来以后我应该每天都和你见上一面聊一聊，这样我至少可以有时间喝杯茶。

ER：哈哈，随时欢迎…

Virtual cognitions: 现在 Kath 的情绪看起来好一些了。“将人和事分开”的策略开始奏效了。[XXX（参与者姓名），你营造了一个更加积极轻松的氛围。你干的漂亮].

我应该继续当个出色的倾听者，稳定她的情绪，顺便收集更多的有用信息。

ER：Kath，看得出你目前正受到一些困扰，能和我再具体说说么？

EE：过去的三个月，我每天都要工作超过 10 小时。长时间的超负荷工作让我精疲力尽。比如上周，我甚至没时间和丈夫说说话。每天一大早我就得离开家，那时候我丈夫还在睡觉，但等晚上回到家，我又已经累到不想说话，只想立马睡觉的地步了。过去的这段日子，我感觉我活得像个机器人一样。

ER: 嗯…这阵子你肯定很辛苦。

EE: 我觉得我每天都是在疲于奔命，早上 6 点半就得起床，8 点前赶到公司，一坐下来就全身心投入工作，直到晚上 8 点才能离开办公室回家。而且每天匆匆吃完晚饭后还得再工作一两个小时。我觉得我手边从未闲过，始终都有活干。

ER：嗯，这样啊……那……

ER：一开始，我以为休个假或许就能让我舒缓焦虑、减轻些压力。度完假，我就能焕然一新，重新振作起来，不过事实证明是我将事情想得太简单了，度个假并不能解决我的问题。

ER：好的，那你现在是怎么想的？

EE：我想，我最大困扰的是我上司对我的态度，他让我非常难受。他总是给我很多工作，而且截止日期往往非常紧张，长期以来，我不得不靠加班来完成工作，他层不出穷的要求让我感到压力巨大。

ER：这……

EE：这听起来是不是不像真的？但我所说的都是真的，一开始我还以为只是特例，不过后来才发现他总是这样对我。而且，我组内的其他同事平时都可以准时上下班，朝九晚五即可，这实在太不公平！

Virtual cognitions: 我已经认识 Kath 好多年了，她在公司口碑不错，但老师曾反复提醒我们，在谈判中要将人与事分开，我可以非常友好，充满善意地对待她，但面对需要解决的问题还是得坚守原则和立场。当她情绪低落时，我作为朋友应该接受她的倾诉，给予她安慰，但另一方面，一旦涉及原则性问题，我还是应该实事求是，不要因为和 Kath 的交情而妥协。现在，虽然根据 Kath 所说，她似乎受到了来自其上司的不公正待遇，但我还是不应该过早下结论，应该试着做进一步探索，挖掘更多的情况和事实。

ER：好的，我了解了。不过你有和上司聊过这些吗？

EE：说实话，我已经在公司工作 5 年了。我非常希望能够升职，这也是为什么我会在他给我那么多工作的情况下依旧对新工作来者不拒，并且在此之前我也从来没有向谁抱怨过他的所作所为。

ER：嗯，了解，那你有没有想过你上司或许也非常欣赏你的工作，在不久的将来就有可能给你升职呢？

EE：不，我不这么认为，他总是对我特别苛刻，从没有因为我超额完成工作或表现优异而给予我任何好的评价和称赞。然而一旦我犯错，即使是很小的错误，他也会严厉地批评我很久，有的时候……有的时候……他……

Virtual cognitions: 将人和事分开，对人温柔意味着应该试着营造一个舒适的谈话氛围，让对方可以畅所欲言。我应该试着让 Kath 尽可能放松下来，让她知道她可以没有顾虑，说任何她想说的话。

ER：嗯，Kath，没关系，你可以畅所欲言，不用担心，这个谈话仅限于我们俩之间。放轻松就行，告诉我吧，发生了什么？

EE：嗯……有时他甚至会在语言上对我进行人身攻击，这让我觉得很受伤。

ER： 额……

EE：你可能会认为他或许是对我予以厚望，因此对我严格要求，对吗？其实一开始我也曾这么认为，因此我曾一度更加努力工作，希望每项工作都能尽善尽美，让上司满意。然而过了好几个月，我才意识到，我只不过是找了个理由寻求自我安慰罢了，因为事实上，无论我多么拼命工作，总有干不完的活在等着我，而且我的上司总是毫无理由的批评我，对我横加指责。

ER：这听起来会让你很受打击，你有没有和你上司提过这件事？

EE：并没有。

ER：额……

EE：其实不是我不愿意和他谈，我试过好多次主动找他，不过每次，他要么说是我想太多，要么就故意把话题扯开。

ER：好的，我了解了。是不是还有其他原因促使你现在提出要离职？

EE：我实在不想再待在这个办公室里了，我非常担心我的工作前景。

Virtual cognitions: 看起来 Kath 确实被目前的工作折磨得不轻，我应该理解体谅她的感受，适时宽慰她一下。不过当涉及原则性问题时，我还是应该让她明确知道根据公司规定，她想立刻离职是不可能的。对人可以温柔，对事要有原则，我牢牢记住这一点，并严格执行！

ER：我想我能理解你的难处，让我们一起想想有哪些可行的处理方案。根据你的合同，因为有两个月的提前通知要求，从你递交离职申请到正式离开公司其实还有两个月的时间得继续工作，其实这个过程是很有必要的，因为得确保你能在离职前将工作顺利交接。因此换句话说，简单的申请离职其实并不能立刻很好的解决你现在面临的问题。

EE：哦！不。我都没有想到这些，我给你写邮件的时候，简直是一团糟！

ER：Kath，没关系，我能理解！让我们继续想想有没有其他方案可以解决这个问题，你现在有收到其他公司的邀约吗？是因为这才急着要在短时间内离职？

EE：并没有，这阵子我完全没时间去找工作，我整天在埋头完成手里的工作，而且最近我丈夫遇到车祸摔断了腿。

ER：什么？摔断了腿？她现在情况如何？具体发生了什么？

EE：她骑车过马路时被摩托车撞了，车祸其实还挺严重的，最后只摔断了腿，还算是比较幸运的了。

ER：是什么时候发生的？

EE：上个月，医生说他至少得在床上休养 2 个月，现在天天都得有人照顾她，另外，平时在家里我丈夫也会帮我分担家务，但现在就得我来做了。

ER：现在有其他人在帮你照顾家庭吗？

EE：有，我父母在帮我照看孩子，不过他们现在年纪也大了，不可能所有事都让他们来做，我也得帮帮他们。既要照顾家人还得同时完成工作，实在非常非常辛苦，一直有个声音在告诉我，我得离开我现在的工作团队，改变我现在的生活。

Virtual cognitions: 我收集了大量关于 Kath 工作及生活状况的信息，并且挖掘了她的潜在利益诉求以及她选择现在离职的潜在原因。

[XXX（参与者姓名），你在共同探索阶段表现非常好].

现在谈判将进入第三阶段：协商讨论阶段，这个阶段，对我来说最重要的一件事就是提出尽可能多的可行方案供 Kath 选择。

ER：完成工作的同时还要处理家里的事宜，肯定很辛苦。

ER：要不由我先和你的上司聊一聊，然后再安排一次我们三人一起的会面，你觉得如何？

EE：不，我觉得已经没有必要这么做了。

ER：额……

EE：我有我自己的理由，两天前，我去茶水间泡茶，碰巧听到了我上司和另一个同事的谈话。谈到我的时候，我上司说我很天真，眼里只有工作，而且非常好控制，他可以很轻松的指使我做任何事。听到这些话我当时就很难过，但更多的是愤怒。我一直努力工作，为此放弃了很多，只是希望能得到领导的赏识，工作上能有好的发展，但原来在他眼里，我竟然只不过是个很好控制的人罢了。

ER：这听起来确实很糟糕，这是个挺严肃的问题，我会找个时间和你的上司好好交流一下。不过现在，我们还是先关注你的问题。你觉得这样如何？你先完成手头的工作，然后我将你调去另外一个组工作。

EE：调去另外一个组？只怕也不是一个好主意，我已经在现在的岗位上奋斗了 5 年，去一个新的项目组可能意味着一切要从头再来，而且还不能排除我可能会遇到和现在一样的领导和情形。

ER：好吧…..

EE：我进入公司已经 5 年了，在我们部门也已经工作了超过 3 年，我完成了很多项目，也帮助公司接到了很多大项目，我相信我完全有资格获得升职。在我现在的岗位上我完全看不到未来。我觉得我现在的工作必须有一些改变，否则也是时候离开了，尽管我现在也不知道能去哪里。

ER：好的，我了解了，确实你在公司每年的年度评估中都表现不错，我相信你正是我们公司需要的优秀员工。要不让你去参加公司的职位晋升面试如何？一旦通过面试，你或许就可以得到更好也更适合你的职位。

EE：晋升面试？什么时候？

ER：两个月前上一轮的晋升面试已经结束，所以如果你想参加下一轮的面试，得再等上一阵子。如果我没记错下一轮晋升面试下个月就会开始。如果你愿意，我可以让你去参加。

EE：还有一个月？时间还是有点长啊。

Virtual cognitions: 公司现在在伦敦有一个工作岗位，如果把这个机会提供给 Kath，我得额外给 Kath 一笔海外工作补助和奖金，这大约需要 3000 欧。至于在伦敦新招募一个员工的费用，可以和招聘一个员工接替 Kath 工作的支出相抵。这么看，3000 欧的方案要比最佳替代方案中 6000 欧的开支要小，我可以试试看 Kath 愿不愿意去伦敦工作。

ER：好吧，公司现在在伦敦的办公室也刚有一个职位空缺，等你完成手头的工作，我们可以把你调过去参加一个由我负责牵头的新项目，你觉得这个方案如何？新的项目，新的环境，我想肯定会给你完全不一样的体验。

EE：听起来不错，我也挺感兴趣，不过很可惜我应该还是去不了。我刚刚提到，我丈夫身体还在恢复阶段，我不能也不想现在离开她去别的地方工作。

ER：好的，我能理解。现在让你出国工作确实不合适，那要不你先继续你手头的工作，同时照顾丈夫，我们帮你先把职位保留，等你丈夫完全康复了，你再带上丈夫孩子一起去伦敦工作，这样如何？

EE：不，我想还是不行，这确实是一次很好的机会，但是我丈夫在这里也有份好工作，等她康复后就得回去工作了，而且如果我们去伦敦工作，孩子没有人照顾，我们就得把他们送去日托中心。这样比较下来，我们还是更希望待在荷兰，我父母可以在我们上班期间帮我们照顾孩子。所以我想我不能接受这个工作。另外，我有点奇怪，为什么荷兰总公司不能给我一个新职位呢？

ER：嗯，我之前也提到了，下一轮荷兰总公司的晋升面试要下个月才开始。

EE：我们已经认识对方好多年了，我相信你知道我的能力和水平，而且你是欣赏我的，对吧？作为公司中最了解我的人之一，为什么不给我个直接升职的机会呢？

Virtual cognitions: “将人和事分开”，我应该在谈判中始终贯彻这种明智的做法，而非被其他私人情感和主观臆断所左右。对人可以温柔，但对事要有原则，我可以尊重和关心 Kath，与其保持良好的关系，但一旦涉及原则性问题，我必须避免将私交掺杂利益，为了利益牺牲感情或者利用交情换取利益。

ER：Kath，我们已经是多年的朋友了，但在公司里我们也是同事，我确实希望能做对你有利的事情，但我同时也得为公司的利益考虑。公司有非常明确和严格的晋升制度，自公司成立以来还还从未有过特例。所以我确实没办法那么做，那样会极大的破坏公司一向推行的公平和透明原则。

Virtual cognitions: 在公司 Kath 不仅是个能力出众的工程师，也是一名经验丰富有很强领导力的员工。虽然给她一个升职的机会，意味着将来需要给她提供更高的薪酬待遇。不过，本来也就要提拔或聘请一个人来担任这个职务。与最佳替代方案的支出相比较，考虑到失去 Kath 可能造成的损失和额外开销，给她一个升职机会并且提供适当帮助依旧是一个更好的选择。Kath 现在看起来对参与下一轮晋升面试有些犹豫，不是特别满意，但似乎还是可以接受的，我应该再试一试，努力一下。

ER：我建议我们还是回到晋升面试上来，我知道三个月对你来说可能有些长，但你已经在公司工作 5 年了，我相信你对公司和工作多少是有些感情的，作为朋友，我想说，以现在的就业形势，想在短期内找到一个新的合适的工作实在不容易，即使是像你这样有丰富工作经验的。至于下次的晋升面试，除了给你参加的机会，我还可以专门为你写封推荐信。

EE：呃…就我所知，这样的晋升面试，不仅公司内部候选人会参加，我还得同时和来自公司以外的申请者竞争，对吗？我会有什么特别的优势吗？

ER：在同等条件下，与外部申请者相比，公司内部的候选人往往会被优先录取。另外我认识一个朋友，他在晋升面试的流程方面有着非常丰富的经验，他既当过被面试者又做过面试官。如果你有意愿，我可以帮你们安排一次会面，你可以和他好好聊聊，问问问题，做些练习。

EE：听起来不错，谢谢你。不过…嗯…一个月，继续待在现在的组里……

ER: Kath，要不我们这样，在接下来的一个月里，如果你能提前完成你手头的项目，我可以在晋升面试前额外给你一些假期，你可以离开办公室去度个假或者你也可以利用这段时间在家为面试做些准备，你觉得如何？

EE：这听起来不错。

ER：好的，我们也确实很希望像你这样的优秀员工能继续留在公司工作，发挥更大的作用。

Virtual cognitions: 很好，基本达成一致了，在共同探索阶段，我给 Kath 提供了尽可能多的可行方案，并巧妙地运用了最佳替代方案。最终我得了能够满足双方利益的方案。

[XXX（参与者姓名），你是个优秀的谈判者]。

到谈判的最后一个阶段了：协议收尾，记得让 Kath 复述我们已经达成的一致协议。

ER：好的，我想我们的进展不错，为了确保不存在其他疑问，你能把我们达成共识的要点再复述一下吗？

EE：行！我们都认可，在未来一个月中我继续完成我手头的工作，而你会安排我参加下一次的晋升面试，同时你还会给我一封推荐信。而且如果我能在一个月内提前完成工作，剩余的时间，我还可以额外得到一些假期。

ER：是的，不过请务必确保在截止日期前完成完成工作，否则我没法给你出具推荐信以及给你额外假期。

EE：好的，了解，完成工作，获得推荐信，参加晋升面试。

ER：都清楚了？

EE：是的，非常清楚。

ER：很高兴能有机会坐下来和你好好聊了聊， 并且我们一起努力找到了解决方案。你正是我们公司需要的优秀员工，所以我很希望你能留下来继续工作。

EE：谢谢你！

ER：不用谢，再见，Kath.

EE：再见！

Virtual cognitions: 太棒了！这是次成功的谈判，最终结果比我最佳替代方案中的情况要好的多。

[XXX（参与者姓名），你挺擅长谈判的]。

这一次，我依旧顺利地依次完成了谈判的四个主要阶段，个人准备；共同探索；协商讨论和协议收尾。

此外，我也成功地在谈判前为本次谈判制定了最佳替代方案，并且在谈判过程中，将新出现的各个提议与最佳替代方案一一做比较，最终找到了更优的而且可以满足谈判双方利益的方案。

与此同时，在这次谈判中，我还运用了老师教给我的一种重要技巧，“在谈判中将人与事分开”，对人可以温柔，对事要有原则。基于这个技巧，我对 Kath 给予了足够的尊重和关怀，并且努力为谈判营造自由和轻松的氛围。不过一旦涉及要解决的问题，我依旧坚持原则，不因为和 Kath 私交甚好就作出妥协。最终，我们双方找到了符合双方利益的方案，实现了共赢，达成了一致。

回顾这次谈判，[XXX（参与者姓名），你是个优秀的谈判者]。

Appendix

Questionnaire items for utility

Table F.1: Questionnaire items for utility

Questionnaire and dimension		Item	
Utility questionnaire	Satisfaction of the training process	Q1	I like practicing in this way.
		Q2	I find such practice enjoyable.
		Q3	Little additional effort is needed to practice in this way.
	Effectiveness in improving negotiation performance	Q1	This method motivates me to practice.
		Q2	It is an efficient way to practice my negotiation skills.
		Q3	It helps me to get used to negotiating with others.
		Q4	It helps me to become less nervous.

The utility questionnaire was adapted from the one used in a study by Kang [117].

Appendix

The negotiation attitude scale and an example of a filled-out questionnaire

The negotiation attitude scale

Below are some statements expressing various beliefs about the confidence as a negotiator.

1. Read all the statements carefully before making any marks, then put a double check mark (√√) in front of the one statement which is ***most acceptable*** to you.

2. Place a single check (√) in front of any other statement or statements which are also ***acceptable***.

3. Now indicate the one statement which is ***most objectionable*** to you by putting a double x (xx) in front of that statement.

4. Place a single x (x) in front of any other statement or statements which are also ***objectionable.***

5. Please do not mark every statement as acceptable or unacceptable; that is, some of the positions can be neither accepted nor rejected (and so be marked as a zero)

_____ 所有人都能在谈判中打败我。Everyone can beat me in a negotiation.

_____ 对于谈判我感到无从下手。I don't know how to start a negotiation.

_____ 面对谈判我会有点紧张。I feel a little bit nervous about negotiating.

_____ 我是个中等水平的谈判者。 I am an average negotiator.

_____ 我对我在谈判中的表现比较满意。I'm fairly satisfied with my performance in the negotiation.

_____ 我是个出色的谈判者。I am an excellent negotiator.

_____ 我在谈判中从无败绩。No one can beat me in a negotiation.

An example of a filled-out questionnaire

__XX__ 所有人都能在谈判中打败我。Everyone can beat me in a negotiation.

__X__ 对于谈判我感到无从下手。I don't know how to start a negotiation.

__√__ 面对谈判我会有点紧张。I feel a little bit nervous about negotiating.

__√√__ 我是个中等水平的谈判者。 I am an average negotiator.

__0__ 我对我在谈判中的表现比较满意。I'm fairly satisfied with my performance in the negotiation.

__0__ 我是个出色的谈判者。I am an excellent negotiator.

__X__ 我在谈判中从无败绩。No one can beat me in a negotiation.

Explanation for the result of this example

If the participant filled in the questionnaire as above, the items that marked as a zero, i.e., “我对我在谈判中的表现比较满意。I’m fairly satisfied with my performance in the negotiation.” and “我是个出色的谈判者。I am an excellent negotiator.” were the participants’ latitude of non-commitment. Next, the item with higher negotiation attitude scale score, i.e., “我是个出色的谈判者。I am an excellent negotiator.”, which matched the interval “6”, was chosen as targeted motivational interval level. Therefore, the statements from this interval, such as “我是个专业的谈判者。I am a professional negotiator.”, were selected for the subsequent training.

Appendix

Knowledge and strategies taught in negotiation training video

The following text was given to participants in the informed condition of the study that validated the video test.

First of all, a successful negotiation usually consists of four major stages. They are: private preparation, joint exploration, bidding, and closing.

In the first stage of negotiation, private preparation, you should do some preparation work for the upcoming negotiation, such as gathering relevant information about the meeting and the other party, figuring out your own thoughts and desires.

What is more, you need to create a BATNA before entering any negotiation. BATNA stands for a best alternative to a negotiated agreement. It is the most advantageous alternative course of action people can take if negotiations fail. In the second stage, joint exploration, you should share information with the other party, learn more about them, what they want and more importantly why they want it. You should not simply focus on the issues but try to find the underlying reason and value behind them.

Something that you should keep in mind is that, a good atmosphere or relaxed climate is quite important for a negotiation. You should try to create a positive climate for the negotiation and make the other party feel free and relaxed in the negotiation.

In the third stage, bidding, you should develop multiple options for the other party to choose from. Do not only insist on one proposal.

Moreover, you should keep the BATNA in mind all the time and compare each new proposal with your BATNA. If the proposal is worse than your BATNA, you should reject it.

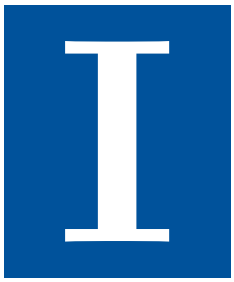
In the last stage, closing, a clear closure of the negotiation is needed. The agreement should be formalized in a way that makes it totally clear for everyone what the agreement is. For example, you could ask the other party to clearly repeat the agreement you have worked out.

Remember: During a negotiation, you should go through the four negotiation stages one by one instead of starting the bidding immediately.

Additionally, during a negotiation, you should separate the person from

the problem. The maxim is be soft on the people, hard on the problems.

Appendix



Frequency of the targeted interval for self-motivational statements used in the three negotiation training sessions

Table I.1: Frequency of the targeted interval for self-motivational statements used in the three negotiation training sessions

Interval	Example statement	Frequency of the targeted interval		
		Training Session 1	Training Session 2	Training Session 3
1	所有人都能在谈判中打败我。 Everyone can beat me in a negotiation.	0	0	0
2	对于谈判我感到无从下手。 I don't know how to start a negotiation.	0	0	0
3	面对谈判我会有点紧张。 I feel a little bit nervous about negotiating.	0	0	0
4	中等水平的谈判者。 I am an average negotiator.	8	6	4
5	我对我在谈判中的表现比较满意。 I'm fairly satisfied with my performance in the negotiation.	8	12	8
6	我是个出色的谈判者。 I am an excellent negotiator.	19	19	20
7	我在谈判中从无败绩。 No one can beat me in a negotiation.	13	11	16

Note, interval level 1-3 were never selected to ensure a minimal level of self-efficacy enhancement.

Appendix

J

Example scripts of virtual cognitions for virtual reality spider exposure

The text of the adaptive condition for spider (Chinese)

一会，房间将会出现一只蜘蛛，它将面朝着你，不过….XXX（参与者姓名）不用担心，你可以应付的了。

蜘蛛其实挺有用，他们可以对付有害的虫子，比如烦人的蚊子，所以有他们在我们周围或许也挺好，人并不是他们的攻击目标。

蜘蛛通常不会主动攻击人除非碰巧被抓到，其实即使被他们咬到，大多数蜘蛛也咬不破人类的皮肤。

当发现屋子里有蜘蛛，其实真的没必要担心。

在接下来的体验中记得敞开心扉，相信会对你有帮助。

试一试吧，这会是一个好的开始，直面恐惧是摆脱恐惧的最好方法！

嗯，他在那…个头不小的一只蜘蛛。

不就是一只蜘蛛么…没事的…你肯定能像现在这样继续直面他…

像现在这样一直盯着蜘蛛看或许是个挑战，但你肯定能应付的了。

像现在这样盯着蜘蛛看，有点紧张很正常，面对自己有点害怕的事物，确实需要很大的勇气。

尽管像现在这样盯着蜘蛛看，你可能会觉得有些不安，但这很正常，你应付的来！

哪有什么危险？你看，你正看着这只蜘蛛，但没坏事发生吧，确实没什么好害怕的！

你正看着的这只蜘蛛确实有点丑，但那又怎样，没事啦，你能应付的来。

眼前的这只蜘蛛爬行的样子确实有点恶心，不过没什么大不了的，能受得了。

你现在正看着这只蜘蛛，但一切都还挺好的吧，你知道，你能行的。

与其像你现在这样不敢看向蜘蛛，故意躲开，不如勇于面对他，这是一种更积极更有意义的态度！直面他！你能行的！

明明知道有只蜘蛛在那，却像现在这样故意避开不看，其实也挺难做到的，而且还挺不好受，直面恐惧有时是一种很好的尝试，甚至是一种更好的选择！

一旦你尝试不再像现在这样一味避开看他，你会发现看两眼蜘蛛其实并不难。

蜘蛛其实不会伤害你，而且如果你现在能试着转过去看他一下，还能更好地掌握他的动态，反而更加放心！

像现在这样选择先不看他，没关系，不过勇于直视蜘蛛才能真正帮助你克服恐惧，积蓄能量直到你觉得准备好了！

加油！没必要一直保持着现在这样不敢看向他的状态，看他一眼没想得那么难，就只是一只蜘蛛啦！

放轻松，没什么大不了的，不用像现在这样一直避开不看他，你做的到的！

像现在这样缓一缓，先不去看蜘蛛完全没问题，积蓄勇气，一会尝试，你很勇敢的，相信自己！

干得不错！有意愿去克服恐惧其实就已经成功了一半，虽然你现在没在看蜘蛛，但你正在努力，试一下看过去，你做得到的！

像你现在这样故意避开不看向蜘蛛，假装他不存在，其实没意义，只是一种逃避，抓住机会直视他才是更聪明的做法！

那只蜘蛛或许也注意到你，但那又如何？没什么大不了，别再逃避，加油！试着看向他！你绝对足够勇敢来面对这只蜘蛛！

听着，没事的，就是一只蜘蛛罢了，你可以应付的来，转过去看下他！

看一眼蜘蛛又能有什么损失？你知道的，蜘蛛很少攻击人，不妨尝试一下，转过去看看他，这一次你可以做到的！

能盯着蜘蛛看越久，就越不会再害怕他，为什么不试一下呢？去看下蜘蛛吧，你不会后悔的。

现在有点害怕很正常，不过完全可以克服，相信自己，你比想象中更勇敢，转过去看下蜘蛛，说做就做！

能够保持冷静，自然地做其他事，其实也是一个很大的进步。别再盯着蜘蛛看一直留意他的动向了！

不要一直再盯着蜘蛛看了，把视线从蜘蛛身上移开！你可以看看其他地方，做其他想做的事情！

把视线从蜘蛛身上移开！如果你觉得蜘蛛的存在已经对你没啥影响，完全不用一直关注他。

别在一直盯着蜘蛛看了，你可以看看别的，蜘蛛的存在没必要影响你。

看看别处吧！你已经知道蜘蛛就在那，确实没必要一直盯着它。如果即使意识到蜘蛛的存在，你还能轻松自在的做其他事，说明你已经克服了对它的恐惧。

迈出第一步总是最难的，即使你现在没在看蜘蛛，但只要尝试就是一种进步！

知道有一只蜘蛛存在，感觉有一点害怕很正常，虽然现在没能看着蜘蛛，但没什么大不了的，一点点恐惧肯定能克服。相信自己，你的勇敢远超想象！

看着蜘蛛爬来爬去并不有趣，但面对他却也并不难。不要像现在这样老盯着别处，你知道你其实能直面他的。

就算一会转过去挑战直视蜘蛛不成功，也不是什么大事，贵在尝试，你知道你自己能处理的好！

知道有蜘蛛，第一反应像这样选择避开很正常，但没事的，就是一只蜘蛛罢了，并不能把你怎么样，不用害怕！

真不用担心，转过去看下蜘蛛并没有你想象的那么难！

相信自己，第一次尝试总是最难的，一旦你转过去看一眼他，或许就会发现蜘蛛并没有很可怕。

完全可以像现在这样先缓一缓不看他，不过一直逃避并不能解决问题，鼓起勇气，试试去看下蜘蛛，你不会后悔的！

不就是一只蜘蛛么？一直像现在这样故意躲着不看他也不是个事，加油，你能做到的！

勇敢一些！不试一下怎么知道自己做不到呢，不用一直到处看，却偏偏不看向蜘蛛，他其实没那么可怕！而且你也远比想象中更勇敢！

知道有只蜘蛛在那，一开始有点害怕而选择不去看他很正常，慢慢来，勇于尝试最重要。

是的！你做到了！面对蜘蛛时，你表现得很好！喔噢，干得漂亮！

在过去的 5 分钟内，你表现得很勇敢，成功完成了所有体验，整个过程都很顺利，直面蜘蛛你做的很好！

这是次很棒的尝试，下一次你肯定能从容地应对蜘蛛，XXX（参与者姓名），好样的！

The text of the adaptive condition for spider (English)

A spider will show up in this room in a few seconds, you will start to face with it. XXX (Name of the participant), don't worry, you definitely can handle that.
Spiders are actual quite useful, they eat many pest insects, for example mosquitoes that can bite you, so maybe it's kind of good to have them around, human is not their target.
Spiders usually will not attempt to bite unless accidentally trapped. Even when they accidentally bite, most spider cannot bite through human skin.
It's really not necessary to feel worried when noticing there is a spider in the room.
Just keep your mind open during the exposure to the spider, it will be quite helpful.
Let's do it. It will be a good start. Facing your fear is the best way to get rid of your scare.
Yeah, there it is. It's a big spider.
It's fine... You are definitely able to continue looking at it like now.
It might be challenging to keep looking at the spider like what you are doing now, but you can handle it.
Now you are looking at the spider, it is normal to feel anxious. It takes a lot of courage to face your fear!
Although you might feel a little bit anxious when looking at it like this, it's quite normal, you can stand it.
Where is the real danger? You see, you are looking at it but nothing bad happened right? It's not necessary to be afraid.
To some extent, this spider you are looking at seems ugly, but it's ok, you can face it.
The way the spider in front of you move is a little bit disgusting, but it's fine. You can handle it.
Now you are looking at the spider, everything is fine, right? You know you can handle this.

Instead of worrying and avoiding looking at the spider like what you are doing now, you could try to face it.
Avoiding looking at the spider like now while it is there takes a lot of effort, too. And it will not get easier like this. Facing your fears is an investment.
Once giving a try to not to avoid looking at the spider like now, you would find it's not difficult.
The spider cannot hurt you. If now you can give a try to look at it, you can also see where it is and what it is doing.
It's fine to choose not to look at the spider immediately, however, looking at the spider can help you to overcome your fear. Gather your courage again when you are ready!
Come on, it's not necessary to keep avoiding looking at the spider, it's not as difficult as you think to glance at the spider. Only a spider.
Relax, it's not a big deal. It's definitely not necessary to avoid looking at the spider like now. You can do that.
Do not look at the spider like now is fine, calm down for a while first, meanwhile try to gather your courage, try later. You are brave. Believe in yourself.
Good job! Although you are not looking at the spider, however, you are trying now, keep on trying to look at the spider, you are able to handle this.
Avoid watching the spider like now is not helping, it is avoidance. Take a chance to look at the spider is a cleverer way.
The spider might stare at you or not, but so what? It is not a big deal. Do not avoid anymore, go for it! You are strong enough to handle that.
Listen, it's fine, just a spider. You can handle this. Start to look at it.
What do you have to lose? You know that, spiders rarely bite humans. It's worth a try. Turn to look at the spider. This time you can do it!
The more you look at the spider, the less scary it will become. Why not give it a try? Look back at the spider. You will not regret it.
It's fine to feel a little bit fear but it can be overcome. Trust yourself. You are brave than you believe. Turn to look at the spider. Just do it.
Being able to keep calm and do your own things naturally is also a big step.

Stop looking out for the spider all the time!
Do not keep an eye on the spider all the time, look away from it! Just do what you want to do.
Turn your gaze away! It's definitely ok if you do not feel the presence of a spider affect you a lot.
Change what you are looking! You are free to look anywhere you want. The presence of the spider does not need to bother you.
Look at something else! You know the spider is there but observing it all the time is not necessary. Sometimes doing other things naturally when you know it's present means you definitely can handle it.
The first steps are the most difficult and you are doing good.
Instead of worrying and avoiding looking at the spider, you could try to face it.
It's definitely not necessary to worry too much about the spider.
Once giving a try to not to avoid looking at the spider, you would find it's not difficult.
You're doing great. Use this time to relax a bit and then try to look at the spider again.
It's fine to feel a little bit fear when knowing there is a spider, but it can be overcome. Trust yourself. You are brave than you believe.
Avoid looking at the spider while it is there takes a lot of effort too. And it will not get easier like this. Facing your fears is an investment.
Normally the spider cannot hurt you. If you look at it, you can also see where it is and what it is doing.
Looking at the spider will help you to overcome your fear. Gather your courage again when you are ready! You might not enjoy watching the spiders, but it will be fine to face it.
Come on, it's not as difficult as you think to glance at the spider. Only a spider.
Yes, you did it! You performed quite well when facing a spider. Wow!... Nice! In the past few minutes, you were brave, you went through the whole exposure.

You did a great job to watch the spider!
It's a really meaningful attempt. XXX (Name of the participant), you are definitely able to deal effectively with spiders next time. Bravo!!!

Appendix

K

Questionnaire items for sense of ownership and plausibility

Table K.1: Questionnaire items for sense of ownership and plausibility

Questionnaire	Item	
Sense of ownership	Q1	I feel I have a strong bond with the voice I heard during the exposure.
	Q2	I felt that the voice I heard during the exposure is part of mine.
	Q3	I feel totally comfortable with the voice heard during the exposure.
	Q4	I feel the voice heard during the exposure is "My" thought.
	Q5	I felt a strong linkage between me and the voice I heard during the exposure.
Plausibility	Q1	The extent to which, the voices you heard during the exposure were responding naturally and appropriately to your exploratory behavior in the virtual environment?
	Q2	The extent to which, the voices you heard during the exposure are credible in relation to what you would have thought in a similar real-life situation?
	Q3	The extent to which, the voices you heard during the exposure are specifically and personally relate to you?

Note, the sense of ownership questionnaire was inspired by several questionnaires [218, 219]. The plausibility questionnaire was an adaptation from the one used by Millevill-Pennel and Charron [217].

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List of Publications

Peer-reviewed papers

- **Ding, Ding***, Mark Neerincx, and Willem-Paul Brinkman. "Simulated thoughts in virtual reality for negotiation training enhance self-efficacy and knowledge." International Journal of Human-Computer Studies, 2020, p.102400.

- **Ding, Ding***, Mark Neerincx, and Willem-Paul Brinkman. "The effect of adaptive simulated thoughts in virtual reality on user's eye-gaze behaviour, ownership perception and plausibility judgement." Submitted to Interacting with Computers (IwC).

- **Ding, Ding***, Mark Neerincx, and Willem-Paul Brinkman. "Technology-based social skills training systems: A systematic literature review." Submitted to International Journal of Human-Computer Interaction.

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- **Ding, Ding***, Willem-Paul Brinkman and Mark A. Neerincx "Virtual reality exposure with eye-gaze adaptive virtual cognitions." The 24th Annual CyberPsychology, CyberTherapy & Social Networking Conference, Norfolk, Virginia, USA, June 24-26, 2019.

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