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1 Virtual Reality for Social Skills Training

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5

Abstract

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Professional work involves a high degree of technical knowledge

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that must be acquired through years of study at school and university. However,

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it also involves other, more implicit, skills that cannot be straightforwardly

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learned from books or lectures. An important example is social skills, interacting

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with other people in potentially challenging professional situations. These social

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skills can only be learned through practice in realistic situations. However, real

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situations do not support the kind of deliberate practice required for improving

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skills. This paper proposes that Virtual Reality can provide a method of

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practising social skills that potentially allows deliberate practice in a safe setting.

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It surveys a range of studies by Mel Slater and colleagues that demonstrate the

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ability of Virtual Reality to reproduce the experience of social interaction. These

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show that people respond realistically to virtual humans, opening up the

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possibility of using them as a means of practicing social interactions. Two

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experiments in particular show this potential for medical training, involving

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general practitioners practising difficult consultations with patients. The paper

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ends with suggestions for what is required to enable deliberate practice of social

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skills in Virtual Reality.

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Keywords: Virtual Reality, Virtual Humans, Social Skills, Learning,

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Deliberate Practice

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Introduction

30 Pioneering Virtual Reality (VR) Researcher, Jeremy Bailenson, in the title of his
31 recent book (Jeremy Bailenson, 2018) proposes that VR allows us to have
32 “Experience on Demand”. VR makes it possible to directly experience a situation,
33 whether it is standing on a plank over a high drop, or walking through a refugee
34 camp, in a way that is not possible in other media. While other media might
35 allow us to watch such an experience at a distance, the immersive nature of VR
36 allows us to feel as if we are experiencing it directly from our own first-person
37 perspective. For Bailenson, a key benefit of this is educational. While many
38 academic subjects can readily be learned from books and lectures, there are
39 certain skills and competencies that can only be learned, or can be learned far
40 better, from experience. Bailenson gives the example of a Quarterback’s
41 decision-making process in American Football. Quarterbacks must make
42 important tactical decisions about what play to make in less than a second. Book
43 learning can help in this context, but actual play is far better, though it is very
44 expensive, and dangerous to practise in a full match. Bailenson and colleagues
45 have shown that VR can greatly improve the effectiveness of quarterbacks’
46 training by immersing them in a play scenario in which they have to make
47 precisely the types of decision they would have to make on the field.
48 Virtual Reality is therefore a powerful medium for the type of experiential
49 learning that is very difficult, if not impossible to learn from books, but can be
50 very expensive or even risky for novices to practice for real. An important
51 example of this type of skill is social interaction. While most of us learn effective

52 social skills for interacting with friends and family throughout our lives, many
53 professions involve complex and difficult social situations that we do not
54 encounter in our daily social lives, whether it is a doctor telling a patient they
55 have a terminal disease or a police officer interviewing a suspect. This position
56 paper will argue that VR is potentially an excellent medium for practising these
57 skills, and will make some theoretical arguments for why that is.

58 It will begin by discussing the challenges of social skills training. It will then
59 explain unique features of VR and why it is so effective for experiential learning.
60 The following sections will discuss virtual characters and the simulation of social
61 interaction in VR, through a description of a series of experiments by Mel Slater
62 and colleagues that show its effectiveness. The paper will then apply the ideas of
63 these experiments to the problem of social skills training.

64 Social Skills Training

65 Donald Schön (Schön, 1983) noted that professional work involves two types of
66 knowledge. The first is technical: engineers need to understand physics and
67 materials and doctors need to understand human biology and pharmacology.
68 This type of knowledge is relatively easily taught in a traditional way with books
69 and lectures, and is the basis of professional training. However, there is another,
70 equally important type of knowledge that is harder to teach. Engineers need to
71 know how to design and doctors how to diagnose. This knowledge is not about
72 following standard procedures, it involves creative thought. What is more, it is
73 not explicit knowledge in the way that physics and biology are, the skills
74 involved are largely tacit, in that practitioners are able to do them, but mostly
75 cannot put into words how they do them. This makes it very hard to teach them

76 explicitly, they can only be learned through experience. Social skills are a clear
77 example of this type of knowledge.

78 What is more, as Ericsson (Ericsson, 2008) has shown, experience itself is not
79 enough. Doctors who are poor diagnosticians can continue to practice for
80 decades without improving. Ericsson's research indicates that what is needed is
81 a particular form of practice called *deliberate practice* which has a number of
82 characteristics (this list is a condensed version of the list in Ericsson & Pool,
83 2016):

- 84 • Deliberate practice is deliberate in the sense that it is focused on
85 improving performance, not simply doing the task. This means having
86 time dedicated to practice itself, rather than simply learning "on the job",
87 otherwise the learner would have to focus on optimal performance on the
88 task, rather than optimal learning.
- 89 • Deliberate practice takes a learner out of their comfort zone. It challenges
90 learners to do tasks they cannot yet achieve (though they should also not
91 be too far beyond the learner's abilities).
- 92 • Deliberate practice requires well defined goals and feedback on progress
93 towards those goals. Learners are able to adapt their learning based on
94 this feedback to ensure they improve their performance.

95 The above three characteristics define a form of practice called *Purposeful*
96 *Practice* which is more effective than naïve practice, but not as effective as full
97 deliberate practice. This requires additional characteristics, particularly the
98 following:

99 • Deliberate practice develops skills that are already well understood and
100 have standardized pedagogies and practice regimens that are supported
101 by a skilled teacher.

102 According to Ericsson (Ericsson & Pool, 2016), deliberate practice aims to
103 develop superior mental representations needed for particular tasks. The term
104 “mental” clearly applies to abstract tasks like mathematics or writing, but
105 Ericsson also applies the term to more physical tasks such as sports or musical
106 performance. In this case it applies to brain circuits that represent physical
107 actions and movements. In Ericsson’s description these are representations of
108 physical movement, but the majority of physical skills are likely to be
109 sensorimotor: the mental representations involved include mappings between
110 sensory input and movement. This view of skills aligns with O’Regan and Noë’s
111 (O’Regan & Noë, 2001) view that perception and action are based on
112 sensorimotor contingencies, lawful relationships between our movements and
113 our sensations. These contingencies are learned. Some in very early childhood,
114 but some are associated with advanced skills are learned later in life, whether
115 they are the sensorimotor relationship between turning a car steering wheel and
116 what we see out of the windscreen or the relationship between pressure and
117 haptic feedback involved in palpation: the medical diagnostic procedure of
118 pressing on a body part. Deliberate practice can therefore be seen as learning
119 sensorimotor mental representations.

120 How do these ideas apply to social skills? Social interaction involves
121 many complex, multi-level mental representations. Some are relatively abstract,
122 such as reasoning about other people’s motivations or beliefs. Others are much
123 closer to sensorimotor skills. Reading facial expressions is a subtle perceptual

124 skill. It may be purely perceptual, but in actual conversation it is important to
125 interpret the relationship between our actions and our partner's responses.
126 Social skills therefore involve complex sensorimotor representations that map
127 the interplay of our verbal and non-verbal behaviour with that of our
128 conversational partner.

129 One important factor, particularly in difficult social situations, is that
130 they are strongly emotionally charged. A doctor breaking bad news to a patient,
131 or interacting with an angry patient, must use all of their social skills effectively,
132 while managing their own complex and potentially challenging emotions
133 (possibly including factors such as work stress and cognitive load). This makes
134 these scenarios very difficult.

135 Social skills and mental representations are largely tacit, we can read
136 expression and pick up social cues without being able to explain how we do it.
137 This places them in Schön's category of professional skills that cannot be learn in
138 the same way as technical knowledge. While some skills, such as reasoning about
139 other people's motivations and goals could be learned from paper scenarios or
140 videos, the sensorimotor skills involved in reading and responding to body
141 language are difficult to learn in any other way than real experience.

142 However, real social interactions are unlikely to support Ericsson's
143 purposeful or deliberate practice. When interacting with a real patient a doctor
144 must attend to the actual situation and cannot focus on their own learning as is
145 required by deliberate practice. Since real social interactions occur naturally, it is
146 not possible to control their difficulty. This means it is not possible to ensure that
147 learners are outside their comfort zone, but not too far. There is unlikely to be

172 Mel Slater (Slater, 2009) has proposed that VR consists of 3 major illusions that
173 can be induced in participants:

- 174 • **Place Illusion** is the illusion that we are transported to a different place,
175 whether real or entirely virtual. Slater's theory is that place illusion is
176 caused by what O'Regan and Noë (O'Regan & Noë, 2001) call
177 Sensorimotor Contingencies, the patterns of relationship between our
178 movements and our sensory perceptions. This is primarily created
179 through head tracking. The ability to turn or move our heads to look at
180 something anchors us in an environment and makes us feel as if we are
181 there, rather than simply watching from the outside.
- 182 • **Plausibility Illusion** is a higher-level illusion that the virtual world we
183 enter is real. While place illusion is caused by low-level sensorimotor
184 correlations, plausibility is caused by higher-level more complex and
185 indirect correlations between our actions and the rest of the world. For
186 example, leaves of a tree moving as we brush past them or another person
187 nodding as we speak.
- 188 • **Embodiment Illusion** is the illusion that the body we have in a virtual
189 world is our body. Like the other illusions it is caused by correlations, this
190 time between the movements of our real body and those of our virtual
191 body.

192 These three illusions are what make a virtual reality experience feel like a real
193 experience. The correlations between our movements and perceptions
194 reproduce those of the real world in a way that other media cannot reproduce.
195 This means that the three illusions are key to why VR is effective for experiential
196 learning. O'Regan and Noë (O'Regan & Noë, 2001) define our experience of the

197 world in terms of sensorimotor contingencies. Slater proposes that VR
198 reproduces these sensorimotor contingencies. Learning in VR is therefore
199 experientially very similar to real world learning. We can therefore learn from a
200 VR experiences as we would from a real experience, but we could not from a
201 book or video.

202 More precisely, any learning is about developing new mental representations, as
203 proposed by Ericsson (Ericsson, 2008). For many physical and practical skills,
204 these representations are sensorimotor representations, in that they represent
205 relations between our actions and our perceptions (for example, the “hand-eye
206 coordination” associated with skills ranging from catching balls to carving
207 wood). Since virtual reality can reproduce the same sensorimotor relationships
208 as the real world, it can enable us to learn sensorimotor representations that
209 carry over to the real world. This is true for a variety of basic sensorimotor skills,
210 but what about social skills? Can VR simulate the experience of interacting with
211 another person?

212 Virtual Humans

213 The power of VR to reproduce real world experiences does extend to social
214 interactions, as shown in a series of experiments by Mel Slater and colleagues.
215 They investigated interactions between people and virtual humans. These virtual
216 humans are animated 3D characters that appear life-sized in front of participants
217 in VR. The characters in these experiments are shown in figure 1.

218 The first experiment was a virtual audience (Pertaub, Slater, & Barker, 2002).
219 Participants were asked to prepare a short speech and then perform it in
220 immersive Virtual Reality in front of an audience of virtual characters, shown in
221 figure 1, top left. The audience was not particularly graphically realistic, even by

222 the standards of the day, but they were programmed to have realistic body
223 language typically of the audience for a business presentation. There were two
224 experimental conditions, each with different body language. The first was a
225 positive audience, which looked at the speaker attentively and smiled and
226 nodded during the presentation. On the other hand, the negative audience had
227 body language that indicated boredom and even hostility. They slouched, looked
228 around, yawned, muttered to each other and even fell asleep or walked out. The
229 speakers with the negative audience performed significantly worse than those
230 with the positive audience. They evaluated their speech significantly worse, even
231 in categories like the quality of their preparation, which should have nothing to
232 do with the audience. Anecdotally, experimenters noted that participants
233 struggled to talk to the negative audience with some even directly criticizing the
234 audience for their behaviour. This experiment, for the first time, showed that
235 people respond to virtual people in immersive virtual reality in a similar way as
236 they would to real people. The participants knew they were not talking to real
237 people (no attempt was made to deceive them), the characters did not look
238 particularly realistic, and though they had convincing body language this was
239 largely pre-programmed, rather than responding to the participant (though
240 there was an experimenter who triggered certain responses at appropriate
241 movements). Nonetheless, participants were affected emotionally by their
242 experience as if they had given a talk to a real audience.

243 This shows people's capacity to interpret and respond virtual characters as if
244 they are real. This was supported by an experiment by Freeman *et al.* (Freeman
245 *et al.*, 2008), in which participants were placed in a VR recreation of a typical
246 commuter train modelled on the London Underground. The researchers were

247 investigating VR as a way of treating paranoid ideation: unrealistic negative
248 thoughts about other people. They therefore created a number of virtual humans
249 to share the underground train. These were deliberately programmed with
250 neutral behaviour that did not respond to the participant (small shifts of posture,
251 occasional looking around). The intention was that it was objectively provable
252 that the characters were not making negative judgements about the participant
253 or behaving aggressively. The experiment cited above was conducted with
254 members of the public, not mental health patients. However, even in the general
255 population a sizable proportion of people showed paranoid thoughts about the
256 virtual characters. For example, "There was an aggressive person - his intention
257 was to intimidate me and make me feel uneasy". Others read positive attitude
258 into the characters: "It was nice, much nicer than a real experience - people
259 aren't so forthcoming with their feelings in a real situation. Thought they were
260 pretty friendly". This shows that people spontaneously interpret virtual humans
261 as if they are real and have emotional responses to them.

262 Slater and colleagues (Slater et al., 2006) also created a VR replication of
263 Stanley Milgram's famous obedience experiments. These controversial
264 experiments involved participants apparently giving electric shocks to other
265 members of the public, even to the level of making the other person lose
266 consciousness. The electric shocks were not real and the other person was, in
267 fact, an actor. However, the experience was extremely traumatic for the
268 participants. The experiments prompted the need for rigorous ethics in research,
269 and it would not be possible to run them now. Slater *et al.* (Slater et al., 2006)
270 however, ran the experiment in VR with a virtual character, without ever
271 attempting to make the participant believe that the character they were giving

272 “shocks” to was real. Despite the virtual nature of the experiment, the majority of
273 experimental participants experienced distress at their actions and a minority
274 did, in fact, feel so distressed that they refused to continue the experiment.

275 These three experiments show that people do respond realistically to virtual
276 characters, even if they consciously know that they are not real. These responses
277 are not simply play acting, but potentially very strong emotional responses. This
278 shows that virtual reality can reproduce the experience of a social situation,
279 including emotional aspects, and therefore has the potential for social skills
280 training. In fact, scenarios similar to the virtual audience are currently being
281 used to help people overcome fear of public speaking¹.

282 However, none of these scenarios is like a normal social interaction, since
283 two-way interaction was absent or severely limited. The London Underground
284 scenario involved no actual interaction. For the virtual audience, the interaction
285 was mostly one way, the participant spoke to the audience. The Milgram
286 recreation could be seen as a two-way interaction, but a highly artificial,
287 formalized one that bears little resemblance to a normal conversation. To
288 address this limitation, Xueni Pan, Slater and colleagues (X Pan, Gillies, & Slater,
289 2015; Xueni Pan, Gillies, Barker, Clark, & Slater, 2012) have developed
290 experiments that involve realistic conversations with virtual characters.

291 Responsive Virtual Characters

292 Both of the experiments used a computational architecture, the PIAVCA
293 model, by Gillies et al. (Gillies, 2008) shown in figure 2. It enables real time,
294 responsive interaction that is both verbal (using language) and non-verbal (body

¹ For example, <http://www.presentationsimulator.com/fear-public-speaking/>.

295 language). It would have been highly challenging to automatically generate real
296 time speech for the kind of free-form conversation using the technology of the
297 time (and it remains challenging with current technology). The PIAVCA model
298 therefore used a Wizard of Oz approach, with an experimenter choosing
299 appropriate utterances from a set of pre-recorded audio clips. However, using
300 Wizard of Oz would not have been possible for non-verbal responses (body
301 language). In part this is because they require very fast responses, faster than
302 would've been possible for an experimenter to respond, but also because body
303 language is largely subconscious, we do it without thinking about what we do,
304 and so an experimenter would not necessarily know what actions would be
305 appropriate in a given context. The PIAVCA model therefore took a semi-Wizard
306 Of Oz approach inspired by the work of Vilhjálmsón and Cassell (Vilhjálmsón &
307 Cassell, 1998). The verbal responses were chosen by an experimenter, but the
308 non-verbal behaviour was generated automatically based on sensor data from
309 the participant. The sensors were similar to those available on a modern head
310 mounted display: 6 degrees of freedom head tracking and voice from a
311 microphone. Though simple, this sensor enabled a range of behaviour such as
312 maintaining a realistic social distance or detecting when the participant was
313 speaking and responding with feedback such as nodding and increased gaze.

314 In the first experiment (Xueni Pan et al., 2012), male participants were
315 approached by a female virtual character in an environment designed to look
316 like a typical bar. The character was able to hold a conversation with participants
317 using pre-recorded speech and realistic body language. All participants engaged
318 the character in conversation. Though the conversation was designed to be
319 pleasant, the scenario is also a potentially stressful one. All participants showed

320 raised biometric markers of physiological arousal. This was particularly
321 pronounced for participants who reported that they were not in a relationship
322 (they were asked this by the virtual character). Again, this experiment shows
323 that people respond realistically and emotionally to characters, and that this
324 effect also applies to full social interactions with virtual humans.

325 A follow-on experiment investigated the effect of a virtual human's
326 personality on the interaction, with a virtual character that displayed behaviour
327 associated with either low or high social anxiety (Xueni Pan, Gillies, & Slater,
328 2015). Participants were asked to interview the character, asking questions of a
329 personal nature that were potentially embarrassing. While the content of the
330 character's speech was the same in both conditions, non-verbal behaviour, both
331 body language and tone of voice, conveyed either social anxiety or confidence. At
332 the end of the interview the character left the room to answer her telephone and
333 did not return. Participants were then left to wait alone. They had been told that
334 they could ring a bell to ask her to return. Participants who had interacted with
335 the anxious character waited significantly longer before ringing the bell. This
336 experiment shows that people obey social norms towards a virtual character,
337 being hesitant to disturb her and also that characters' non-verbal behaviour can
338 have a significant effect on people's responses to them.

339 Taken together, these experiments show that virtual reality is able to
340 reproduce social experiences in a way that prompts people to respond
341 realistically, both in terms of behaviour and emotion. This is largely due to
342 people's ability to read realistic intentions into a virtual human's behaviour. In
343 particular, people interpret virtual humans' behaviour as responding to them. In
344 the case of the bar experiment, the character's behaviour was genuinely

345 responsive, but in the case of the London Underground experiment, participants
346 interpreted the behaviour as responding to them, even though it was not. In both
347 cases the characters' behaviour is an example of plausibility illusion: a virtual
348 environment that is interpreted as correlating with the participant's behaviour.
349 These are likely to be examples of learned social sensorimotor contingencies,
350 relationships between one person's actions and their perception of their
351 conversational partner. A simple example is the relationship between a
352 participant's speech and the virtual human's feedback behaviour such as
353 nodding or smiling.

354 The success of these experiments opens up the possibility of using virtual
355 reality for professional social skills training. The following section describes two
356 experiments which look specifically at professional social skills for medical
357 practitioners and which could be used for training.

358 VR for Medical Social Skills

359 Medical practitioners need to interact with other people in many difficult
360 and highly stressful situations, including cooperating with other professionals on
361 high pressure procedures, telling patients that they have fatal diseases, or
362 dealing with demanding patients. These require complex social skills, but
363 training is very difficult because the situations involved are highly safety critical
364 or high pressure and it is difficult to allow trainees to have access to them in real
365 life. Virtual Reality could therefore be an excellent way to practice this skill, as
366 shown by the work of Benjamin Lok and colleagues (Kleinsmith, Rivera-
367 Gutierrez, Finney, Cendan, & Lok, 2015; Robb et al., 2016). This section describes
368 two experiments by Pan *et al.* which involve VR recreations of difficult social
369 situations typical of medical practice.

370 The first experiment (Xueni Pan et al., 2016) involved general practitioners
371 (family doctors). One of the most difficult situations for modern doctors is
372 antibiotic prescription. Prescribing antibiotics in large quantities increases the
373 possibility that a new bacteria will emerge that is resistant to these drugs, raising
374 the spectre of many deadly and untreatable diseases. So antibiotic resistance is
375 in many ways caused by doctors prescribing antibiotics when they should not.
376 This tendency to prescribe is in large part due to pressure from patients, who
377 perceive that antibiotics will help them even if they are not medically
378 appropriate (for example for flu and colds). In the experiment, experienced
379 doctors and trainees had a consultation with a virtual woman and her virtual
380 mother who is presented as suffering from an illness that clearly should not be
381 treated with antibiotics. The woman was very insistent that her mother should
382 have antibiotics and did not accept any of the doctors' arguments that they were
383 not appropriate.

384 The results were striking. Of the 9 trainees tested, 8 prescribed antibiotics.
385 Of the 12 experienced doctors, 7 prescribed antibiotics. These results are
386 remarkable. The doctors were all aware that the patients were not real, no
387 attempt was made to deceive them. They were all also aware of the dangers of
388 antibiotic resistance and the importance of not prescribing antibiotics. They
389 were also aware of being watched by an experimenter who may have judged
390 them as less professionally competent for prescribing antibiotics. Nevertheless, a
391 large majority did prescribe. This indicates that the doctors felt subject to social
392 pressure from the virtual patients in much the same way as they would from real
393 patients.

394 This result supports the conclusions of the other studies described above:
395 that people respond realistically to virtual people, and in particular respond with
396 realistic emotional responses. In addition it shows that virtual humans can
397 reproduce the kind of social pressure that we are subject to in many difficult
398 social situations. In particular, it shows that it can reproduce the key social and
399 emotional elements of professional social situations. At the moment
400 professionals perform as badly in VR as they would in the real world. However,
401 because it is sufficiently realistic experientially, it also has the potential for
402 improving doctors' performance because they can practice in a virtual situation
403 that reproduces many of the key features of the real situation.

404 The second experiment (Xueni Pan et al., 2018) concerned another
405 important task for general practitioners: child safeguarding. In the UK, doctors
406 are required to identify and report potential child abuse issues. This is a difficult
407 task given that they only typically have 10 minutes with patients and their
408 consultations will concern medical issues which may be unrelated to any abuse
409 that is occurring.

410 The scenario designed involved a consultation with an adult male
411 patient seeking advice on surgery for a serious medical condition. The patient
412 brought along his son to the consultation. Though the consultation was about the
413 father's health and no issues around safeguarding were explicitly raised, there
414 were several cues to child abuse (there were two conditions, with stronger and
415 weaker cues).

416 The doctors' ability to detect the cues depended on the level of cue
417 (doctors were more likely to detect abuse with more obvious cues) and also their

443 This survey of experiments shows that VR scenarios with virtual
444 humans are able to recreate the experience of difficult social interaction,
445 suggesting they can be used for learning social skills. In particular, they
446 reproduce many of the implicit and emotional aspects that make social skills so
447 hard to learn and practise in other ways.

448 Compared to real professional situations (e.g. real medical
449 consultations), VR is cheap and low risk. This makes it very suitable for
450 practising social skills. However, following Ericsson (Ericsson, 2008; Ericsson &
451 Pool, 2016), experience and practice are not sufficient for developing true
452 expertise. The practice must be *deliberate* in the sense that it must conform to a
453 number of constraints. Let us examine each in turn to see how VR training
454 supports it.

455 The practice must be deliberate in the sense that it must be for the
456 explicit purpose of improving performance, not simply for performing as well as
457 possible, and learners must attend explicitly to improvement. VR is well suited to
458 this kind of practice because it is not a real situation. In a real consultation
459 doctors must attend to performing as well as possible for the benefit of the
460 patient, not to improving their own performance. The fact that the situation does
461 not have the pressure of real performance can give learners more space to be
462 aware of and reflect on their performance.

463 The practice must push learners outside their comfort zone, but not too
464 far. The two scenarios described above were challenging for participants.
465 However, repeated practice with the same scenario would quickly become easy.
466 This raises the importance of having a wide range of scenarios and that these
467 scenarios present different levels of difficulty so they remain challenging as the

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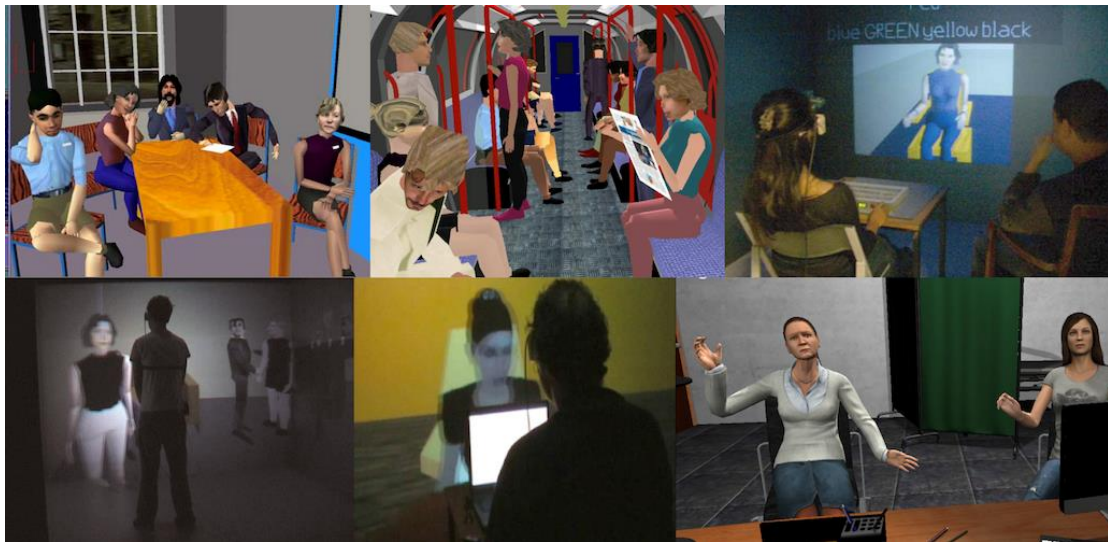
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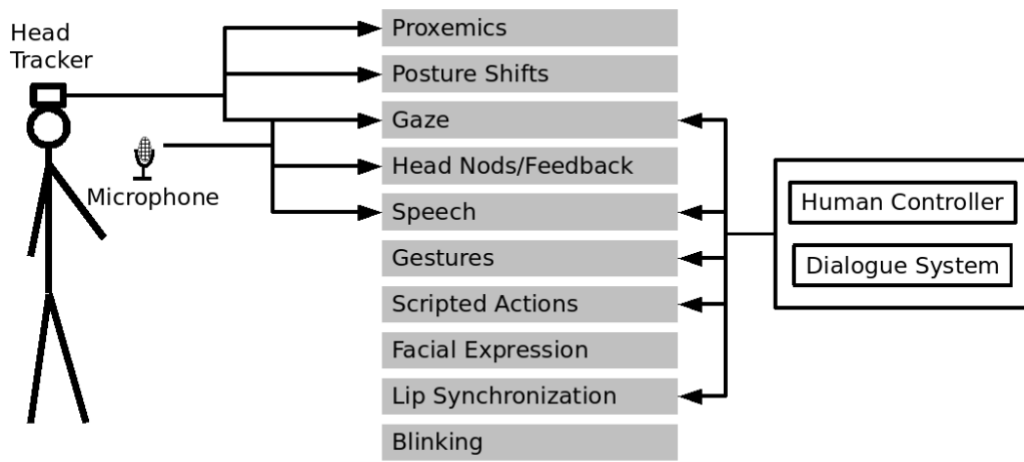
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569 Figure 1: Slater's experiments on Virtual Characters. (left to right and top to
570 bottom): the virtual audience(Pertaub et al., 2002), the London underground
571 (Freeman et al., 2008), the Milgram recreation(Slater et al., 2006), the virtual
572 bar(Xueni Pan et al., 2012), the socially anxious virtual character(X Pan et al.,
573 2015) and the medical consultation(Xueni Pan et al., 2016).

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579 Figure 2: The PIAVCA model of virtual character behavior used in most of the

580 experiments discussed in this paper.