Interviewing in virtual environments: Towards understanding the impact of rapport-building behaviours and retrieval context on eyewitness memory

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Abstract

Given the complexities of episodic memory and necessarily social nature of in-person face-to-face interviews, theoretical and evidence-based techniques for collecting episodic information from witnesses, victims, and survivors champion rapport-building. Rapport is believed to reduce some of the social demands of recalling an experienced event in an interview context, potentially increasing cognitive capacity for remembering. Cognitive and social benefits have also emerged in remote interview contexts with reduced anxiety and social pressure contributing to improved performance. Here, we investigated episodic memory in mock-eyewitness interviews conducted in virtual environments (VE) and in-person face-to-face (FtF), where rapport-building behaviours were either present or absent. Main effects revealed when rapport was present and where interviews were conducted in a VE participants recalled more correct event information, made fewer errors and were more accurate. Moreover, participants in the VE plus rapport-building present condition outperformed participants in all other conditions. Feedback indicated both rapport and environment were important for reducing the social demands of a recall interview, towards supporting effortful remembering. Our results add to the emerging literature on the utility of virtual environments as interview spaces and lend further support to the importance of prosocial behaviours in applied contexts.

Keywords Eyewitnesses · Episodic memory · Virtual Environment · Rapport · Cognitive Resources

Introduction

The information provided by witnesses, victims and survivors[1] is fundamental to the investigation of crime and prosecution of perpetrators. When providing an account, witnesses are asked to reconstruct and recount personally experienced episodes that occurred in a particular temporal and spatial context (Tulving, 1993). Episodic memory is a complex cognition which conceptually comprises several distinct components—what, when, and where—accompanied by a feeling of reexperiencing (Conway & Pleydell-Pearce, 2000; Tulving, 1993). Witness information is usually collected during an interview, typically conducted in person, face-to-face by a police officer or similar professional investigator. Given the complexities of episodic memory and

necessarily social nature of face-to-face interview contexts, many theoretical and evidence-based witness interview techniques champion rapport-building as a technique to support the development of a positive interaction and help manage the power imbalance between the professional interviewer and witness (e.g., Ministry of Justice, 2022—Cognitive Interview; National Institute of Child Health and Human Development Protocol; PEACE Model).

Rapport-building, also referred to as prosocial behaviour or supportive/attentive behaviour, is believed to be important for relieving some of the social demands of an interview (e.g., Kieckhaefer et al., 2014; Nahouli et al., 2021; Roberts et al., 2004; Webster et al., 2021), potentially increasing cognitive capacity for remembering (Dando et al., 2016; Fisher & Gieselman, 1992; Milne & Bull, 2016; Nahouli et al., 2021; Webster et al., 2021). Comfortable witnesses may well be better placed to devote finite cognitive resources to complex cognitions, here recalling episodic experiences (e.g., Fiske & Taylor, 2013; Frith & Frith, 2012; Gallese

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1 From here on we use the term witness to refer to witnesses, victims and survivors of crime.

et al., 2004). It seems sensible to suggest that socially comfortable witnesses will be "better" witnesses; however, the experimental rapport-building literature in this regard is limited. There is no widely agreed definition of rapport, and as a recent review has revealed, the experimental literature has tended to emphasize verbal rapport-building (see Gabbert et al., 2021). Presumably, because verbal behaviour is more straightforward to operationalise, control, and analyse than nonverbal behaviour. Furthermore, research findings are very mixed, likely because rapport is often subjectively described, for example as a bond, a connection to another, and a communicative alliance, and rapport behaviours are variously operationalised, both theoretically and empirically. Further, different clusters of rapport behaviours are applied, and rapport is not measured consistently across studies.

Rapport-building is not a prescriptive process and is thought to comprise a wide range of

physical and/or verbal behaviours. In investigative interview contexts rapport-building behaviours are generally thought to be verbal, facial, and physical in nature. Examples include active listening (smiling, nodding, & uh-huh), immediacy behaviours (eye contact & leaning forward), self-disclosure (Abbe & Brandon, 2014), tone of voice and empathy (e.g., Baker-Eck et al., 2020; Dando & Oxburgh, 2016; Griffiths & Rachlew, 2018; Jakobsen, 2021), and personalising the interview (Fisher & Geiselman, 1992). Indeed, professional training materials and guidance for conducting interviews with witnesses emphasize and describe various rapport-building behaviours. For example, the Cognitive Interview technique (Fisher & Geilselman, 1992), UK College of Policing (2021) and the Norwegian Police College (Fahsing & Rachlew, 2009; Rachlew & Fahsing, 2015) all suggest several verbal behaviours, including personalising the interview process by "introducing yourself," interacting meaningfully with the witness "making it feel like a two-way conversation," and making the conversation "natural and simple." Less guidance is offered on nonverbal behaviour, simply that head-on face-to-face interactions should be avoided and that interviews should be calm, and interviewers should respect witnesses' personal space. The recent Ministry of Justice (2022) Achieving Best Evidence guidance suggests, for example, beginning by conversing about neutral topics using easily answered, predominantly open questions, and using supportive behaviours such as active listening (Achieving Best Evidence guidance relates to England and Wales). The PEACE investigative interviewing model (relevant to England and Wales), the PRICE model (relevant to Scotland), and the Norwegian KREATIV national investigative interviewing training program emphasise the use of neutral open questions in establishing rapport in terms of supporting the witness to answer positively to create a positive mood. The Cognitive Interview (Fisher & Geiselman, 1992) suggests rapport can be built and maintained by

personalising the interview process, interacting meaningfully with the witness, being attentive and transferring control of the interview from the interviewer to the witness (Memon & Higham, 1999).

Despite varying operationalisations of rapport-building, there is consensus that *some* rapport-building behaviour is better than none for positive outcomes (e.g., College of Policing, 2018; Gabbert et al., 2021; Ministry of Justice, 2022; Milne & Bull, 1999; Nahouli et al., 2021; Nash et al., 2014; Nash et al., 2016; Walsh & Bull, 2012), although experimental research findings are mixed. Some research indicates witnesses can provide more complete and accurate accounts when rapport-building behaviours are present (e.g., R. Collins et al., 2002; Holmberg & Madsen, 2014; Nahouli et al., 2021; Nash et al., 2016; Vallano & Shreiber Compo, 2011; Novotny et al., 2021), but this is not always the case (see Kieckhaefer et al., 2014; Sauerland et al., 2018). For example, verbal rapport-building (unaccompanied by appropriate behaviours) has been found to increase information yield (e.g., Novotny et al., 2021), whereas some have reported that verbal behaviour alone is less effective (e.g., Nahouli et al., 2021). In a similar vein, extensive rapport-building (comprising both verbal and behavioural techniques), has been reported to improve recall performance (e.g., Collins et al., 2002; Kieckhaefer et al., 2014; Nahouli et al., 2021), while others have reported no positive impact (e.g., Meissner et al., 2015; Sauerland et al., 2018). A recent review of the use of rapport by professionals during interviews with witnesses and suspected offenders/persons of interest has indicated that some form of rapport does improve outcomes in the majority of cases reviewed (Gabbert et al., 2021).

Most experimental rapport research has employed traditional in-person face-to-face interview paradigms (although see Drolet & Morris, 2000; Nunan et al., 2020). Yet the COVID-19 public health emergency has forced organisations to consider virtual or remote interview solutions, bringing into sharp focus just how little remote interviewing research has been conducted. Rapport-building in remote information gathering interviews has received little attention versus traditional in-person face-to-face contexts despite increasing digital adoption that is changing the way that organisations do business, including police and government bodies (e.g., national crime agency). Here, we investigate witness memory in remote virtual environments and explore the impact of a cluster of basic rapport behaviours that are drawn from contemporary best practice guidance, and which are theoretically and empirically supported (see below).

Virtual environments as interview spaces

Virtual environments (VEs) are immersive computer simulations with a high degree of realism (Loomis et al., 1999;

Taylor & Dando, 2018; Witmer & Singer, 1998) that offer opportunities as remote witness interview spaces. VEs render visual, auditory, and haptic information within milliseconds, bringing about realistic behaviour because the environment "feels" real, thus leveraging behavioural responses to environmental changes and challenges (e.g., Slater, 2009; Gonzalez-Franco & Lanier, 2017). VEs can be quickly and remotely created and managed using widely accessible portable computer and smartphone technology. In VEs, people communicate as *avatars* (see Ahn et al., 2013), which allows them to interact realistically albeit in the absence of physical co-presence (Baccon et al., 2019; Kang & Watt, 2013). The extant literature on avatar-to-avatar communication highlights potential cognitive and social benefits, suggesting interviews in VEs may be as efficient as face-to-face in-person witness interviews in some instances.

Non-investigative interviewing research, that is research concerned with interviews conducted for reasons other than the investigation of crime, reveals improved outcomes and better interviewer/interviewee experiences. Examples include enhanced disclosure of information (e.g., Baccon et al., 2019; Joinson, 2001; Suler, 2004) and reduced performance anxiety (e.g., Omarzu, 2000; Rubin, 1975). Interviewees and interviewers have also reported less social pressure (Baccon et al., 2019; Herrera et al., 2018) and increased confidence (e.g., Salmon et al., 2010). More recently, online simulation training using avatars was found to improve the quality of clinical psychologists' interviewing (Haginoya et al., 2021; Pompedda et al., 2022). Avatar-to-avatar nonverbal communication has also been found to increase co-operation, lowering the need for additional verbal interactions to achieve efficient outcomes that require social co-operation (Greiner et al., 2014). Similarly, improved interpersonal trust and more impactful nonverbal behaviours have been reported when communicating avatar-to-avatar versus other communication contexts (e.g., Bente et al., 2008; Roth et al., 2017; Segal et al., 2022).

As far as we are aware the only published research conducted in a VE with mock witnesses is that by Taylor and Dando (2018) who found some advantages of gathering witness information in VEs akin to some of the benefits reported in the non-investigative literature. Episodic performance improved, with a significant reduction in errors, mirroring positive findings reported by others where memory and related cognitions were investigated in a VE (Bailenson et al., 2008; Saidel-Goley et al., 2012). Taylor and Dando also reported that the VE was well received. Interviewee experiences were extremely positive, including participants feeling more comfortable explaining when they did not know the answer or could not remember and enhanced concentration, which may have contributed to improved performance.

This pattern of results alongside findings from the wider literature suggest improved performance in a VE may emanate from a combination of reduced social demand (typically experienced in human-to-human interactions) and an absence of external stimuli, potentially reducing a dual cognitive task (episodic remembering and social monitoring) to a single task (remembering). Avatars represent the presence of another, offering social and communication benefits but without being physically co-present, perhaps limiting the potentially confounding influence of others on cognition, including memory (e.g., Brewer & Feinstein, 1999; Fiske, Lin, & Neuberg, 2018; Macrae & Bodenhausen, 2000; Maddox et al., 2008). Given that episodic recall is a demanding cognitive task, requiring a subjective sense of time (mental time travel), and a connection to the self and autonoetic consciousness, it is reasonable to suggest that an absence of external stimuli and better managed social demand will support improved performance.

Remote rapport-building

Numerous positive benefits of rapport-building in remote avatar-to-avatar communication have been reported, including inducing strong feelings of positivity (Rehm et al., 2016), improved social engagement (Peyroux & Frank, 2014), and increased self-disclosure (Lee & Dryjanska, 2019; Pickard et al., 2016). However, as far as we are aware, no experimental rapport-building research has been conducted in VE interview spaces with witnesses. In Taylor and Dando's (2018) study a formal rapport-building phase was not included, although an informal and friendly conversation did take place prior to the start of the retrieval interview, during which the interviewer used positive nonverbal behaviours (e.g., eye contact, nodding). These behaviours are argued as being key rapport-building techniques (see Abbe & Brandon, 2014) and studies have found them effective (e.g., Collins et al., 2002; Holmberg & Madsen, 2014; Nahouli et al., 2021; Vallano et al., 2011; see Gabbert et al., 2021, for a review). However, these behaviours were common to all conditions, hence rapport was not manipulated nor was it the focus of the research.

Some research has remotely manipulated rapport, and rapport has been investigated in face-to-face video mediated contexts and during the remote production of facial composite sketches (e.g., Kuivaniemi-Smith et al., 2014; Nash et al., 2014; Nash et al., 2020; Sun, 2014). Although markedly different interview environments, the findings are encouraging, suggesting that rapport can be built remotely, and where this occurs interviewees reveal more sensitive information, and the accuracy of witness accounts improves versus where rapport was absent. Furthermore, interviewees report better concentration and feeling less pressured. In common with traditional in-person face-to-face paradigms, a variety of rapport behaviours were employed including informal and friendly conversation, eye contact, reciprocal

Table 1 Interview phase description

Phase	Overview
1. Explain	Explain the interview/research process prior to the commencement of the interview and offer the opportunity to ask questions.
2. Rapport	Interviewer verbally interacts with the participant using two behaviours: i) Open-ended invitations to exchange information. For example, "*Thank you for coming to the University today. It's quite tricky to find us; how did you get here?*" ii) Offering some nonpersonal information about themself to begin this process. For example, "*I ride my bike here, but I worry about my bike being stolen. One was damaged last year.*" Interviewer displays two attentive physical behaviours: i) Looking at interviewees/making eye contact when they were talking ii) Nodding when interviewees speak/answer questions Interviewer displays two attentive verbal behaviours: i) Referring to the interviewee by their first name once the interviewee had agreed this would be acceptable ii) Thanking interviewees whenever they provided information and answered a question. For example, "*Thank you, that was useful in helping me to understand.*" In the rapport-present condition, the two physical and two attentive verbal behaviours continued throughout both the free-recall and questioning phases (see Gabbert et al., 2021; Nahouli et al., 2021).
3. No Rapport	The interviewer immediately moves from the Explain phase (Phase 1) to the Free-recall phase. None of the above verbal or physical behaviours are used. This persists throughout the interview.
4. Free-recall	Commenced with an explanation of the four ground rules: 1. Report all/everything 2. Do not guess 3. Say if you do not know 4. Say if you do not understand Participants were then instructed to explain everything they could remember, uninterrupted by the interviewer. The interviewer made bullet-point notes regarding the topics recalled and the order in which they were recalled for use during the questioning phase. Once interviewees had finished, all were asked if they wished to add anything else.
5. Questions	Commenced with a reminder of the four ground rules (above), following which participants were asked one TED prefaced probing question related to each of the topics recalled in the free-recall, one by one. For example, "*You mentioned a girl standing at the bar, please **describe** that girl to me in as much detail as you can.*"
6. Close	Participants were thanked and offered the opportunity to ask questions.

conversation, friendly tone, use of first name, and appearing interested and engaged.

Although the wider literature indicates potential benefits of VEs as interviewing spaces and possible advantages of avatar-to-avatar rapport (e.g., Mousas et al., 2018; Saarijärvi & Bratt, 2021; Sutherland, 2020) more research is needed. Here, we report a mock eyewitness study where a cluster of rapport-building behaviours were experimentally manipulated in traditional in-person face-to-face and VE avatar-to-avatar interview contexts. We selected a small number of physical and verbal rapport behaviours described in the applied experimental literature (e.g., Collins et al., 2002; Kieckhaefer et al., 2014; Nahouli et al., 2021; Vallano & Schreiber Compo, 2011), the prevailing professional interviewing guidance (e.g., College of Policing, 2021; Ministry of Justice, 2022), and which were appropriate for use both in a VE which neccesitates the use of a headset, and face-to-face contexts, as follows. In the rapport-present conditions, to begin the process of engagement, the interviewers commenced the rapport phase by offering some non-personal information about themselves, interacting with the participant using open-ended invitations to exchange information about neutral topics. Simultaneously, the interviewers displayed two attentive physical behaviours—namely, looking at interviewees/making eye contact when the interviewee was talking (as appropriate) and nodding when the interviewee spoke and answered questions. Two attentive verbal behaviours were also used—namely, referring to the interviewee by their first name and thanking the interviewee whenever they provided information/answered a question. Both verbal and physical behaviours continued throughout the interview (see Table 1) in the rapport-building conditions only and were absent throughout interviews in the no-rapport conditions. Although data collection was completed prior to the publication of a review of rapport in professional contexts (Gabbert et al., 2021), the rapport behaviours used here are all highlighted as key methods for building rapport.

In light of the extant empirical literature concerning interviewee experience and memory performance, we formulated a number of hypotheses. First, being interviewed in a VE will improve mock witness memory versus an in-person face-to-face interview (H[1]). Further, irrespective of interview context some rapport-building will improve mock witness memory performance (H[2]) since previous research has highlighted the importance of rapport for improved cognition . Finally, irrespective of interview environment

rapport-building will have a positive impact on self-reported interview experience (H[3]) because the literature generally reports improved social benefits when rapport is present. We do not hypothesise regarding the impact of rapport as a function of interview environment since relevant literature is sparce and does not support a meaningful hypothesis in this regard. Rather, we investigated rapport across environments by considering interaction effects guided by the following research question—is rapport important and impactful in a virtual environment as the literature suggests it is during face-to-face interactions.

Method

Participants

An a priori power analysis using G*Power 3.1 (Faul et al., 2007) indicated that a sample size of 100 mock witnesses would be more than adequate to detect large effects (assuming power = .80 and a = .05). Forty-four males and 56 females from the general population participated with a mean age of 25.8 years (SD = 7.5), ranging from 18 to 50 years. There were no significant differences in mean age across conditions (rapport & environment), F = 1.46, p = .23. Participants were recruited through word of mouth, social media, and advertisements placed in the locality of the University.

Design

A mock witness 2 (environment: face-to-face, virtual) × 2 (rapport: present, absent) design was employed using five interviewers, as typically occurs in real-life cases where there are several witnesses. The mean number of interviews conducted by each interviewer was 20 (ranging from 11 to 32). Participants individually watched a stimulus video and were then randomly allocated to one of the experimental interview conditions. Forty-eight hours later, participants were interviewed according to condition. The dependent variable was memory for the video, measured by the number of correct, incorrect and confabulated information items recalled, and percentage accuracy (correct details as a function of overall details recalled). Immediately post interview, feedback was collected to understand interviewee experience. Ethical approval was obtained from the University of Westminster research ethics review committee.

Materials

Crime stimulus video A pre-recorded video lasting 1 min 40 seconds of a mock fight in a public bar was viewed individually by participants via a laptop computer (see https://youtu. be/4PumXJX1iZo). The video depicts a man buying drinks for a female friend while another female character walks over to chat about a coursework assignment. The second female character leaves and the male and female then walk to the other side of the bar where they sit down at a table. Their conversation is interrupted by two men, first talking and then shouting. One of the men pushes the other before punching him to the ground and repeatedly punching him. The male friend goes over and states he is unconscious. A woman who is sitting behind them calls an ambulance.

Interview protocols Irrespective of condition, all interviews comprised two retrieval attempts in the same order. First, participants were asked to provide a free-recall account of everything they could remember. This initial account was uninterrupted by the interviewer who made bullet point notes regarding the topics recalled and the order in which they were recalled for use during the questioning phase that followed. In the questioning phase, each of the topics recalled in the preceding free-recall phase were probed in turn using one Tell, Explain, and Describe question per topic. Probing questions commencing with Tell, Explain, and Describe are often referred to as TED questions and are recommended as part of several evidence-based interview protocols. TED questions are open, probing, information gathering questions that prompt the interviewee to elaborate in detail on topics that have been previously mentioned in the initial free-recall prompt (see Kontogianni et al., 2020; Oxburgh et al., 2010). Accordingly, the number of TED questions asked during the questioning phase was predicated on participants' free-recall (see Dandoet al., 2020 ; Fisher & Geiselman, 1992; Vrij et al., 2014).

The free-recall commenced with a pre-interview explain phase and finished with a closure phase. Participants in the rapport condition experienced an additional rapport phase, with all rapport-building behaviours then continuing throughout the interview. Participants in the no-rapport conditions did not experience the rapport-building phase, and the rapport behaviours were all absent through the entire interview. Interview protocols are outlined in Table 1 (detailed protocols are available from the first author). The questioning phase commenced with a reminder of the four ground rules. Five experienced researchers conducted all the interviews, following the condition appropriate protocols, verbatim (but see Procedure and Fig. 1 also).

Post interview questionnaire All participants completed an anonymous post interview questionnaire within 15 mins of being interviewed. The questionnaire was hosted remotely on Qualtrics. The questionnaire comprised a total of ten questions, however, participants answered questions according to condition (see below). Nine questions used a Likert type scale ranging from 1 to 5 (e.g., 1 = *very easy* to 5 =

Fig. 1 VE environment view at point of entry

Fig. 2 Avatar and environment example

v*ery hard*; 0% confident to 100% confident etc.), allowing participants to select one of the 5 response options. One question was dichotomous yes/no (full questionnaire available from first author). All participants were asked the following five Likert scale questions: (i) how easy/difficult did you find it to remember the video, (ii) how confident are you that what you remembered was correct, (iii) how confident are you that you did not make any errors, (iv) how comfortable did you feel during the interview, (v) how easy/difficult was it to say when you did not remember, and (vi) how friendly/unfriendly did you feel the interviewer was towards you during the interview. Participants in the VE condition were asked the following three Likert questions relating to the VE and VR headset:(i) how easy/difficult did you find it to use the VR headset, (ii) how comfortable was the VR headset, (iii) overall, how easy or difficult was it to be interviewed in a VE, and (iv) 3 likert scale questions and one final dichotomous yes/no question (have you used a vr headset before- yes/no).

Equipment In the VE condition, interviewer and participant were in different rooms within the same building and communicated using an Oculus Rift S virtual reality (VR) headset. The Oculus Rift creates a sense of complete immersion in a three-dimensional world (here, a bespoke interview environment) via 2,560 × 1,440 high-resolution OLED panels, one for each eye, which globally refresh at a rate of 90 Hz. An on-board Inertia Measurement Unit (IMU) positional camera allows transitional and rotational movement to be tracked with 6 DoF. The headset tracks the movements of both head and body, then translates them into VR with realistic precision. Verbal communication was via 3D positional audio built directly into the headset, which was digitally recorded for transcription and coding. A bespoke, virtual interview environment was developed for this research using Unreal Engine 4. The VE interview environment was purposely sparse and neutral, comprising a sofa, a table and chairs—one chair for the avatar interviewer, the other for the avatar participant (see Figs. 1 and 2). Limited choice

was offered to participants regarding the appearance of their avatar, likewise the interviewers. They could appear as male or female. Participants and all interviewers chose to match their avatar to their gender appearance.

Procedure

Participants were recruited to take part in a mock eyewitness research study investigating the use of virtual environments for investigating long term memory performance. The study was advertised via social media, locally around the University, and via word of mouth. Interested participants were able to contact the researchers, at which point they were provided with an information sheet and consent form, which outlined some inclusion criteria, including being over 18 years of age, and not ever having been interviewed as a witness or victim of crime. Once participants had met the inclusion criteria and then consented to participate, they accessed a one-time-only link which allowed them to view the stimulus video. They were interviewed about the video 48 hours later. In the UK and elsewhere, other than for the most serious crimes, witnesses are not usually interviewed immediately (see Hoogesteyn et al., 2020; Hope et al., 2011). Rather, for more common "volume" crime events such as depicted in the stimulus video used here, delays in interviewing can often range from several hours to several days. Hence, as is common practice in research of this nature, we too introduced a delay to enhance the ecological validity. Prior to interview, participants were randomly assigned to one of the interview conditions (face-to-face rapport, face-to-face no rapport, VE rapport, VE no rapport) and interviewed accordingly. Participants completed the post interview feedback questionnaire within 15 mins. Participants took part voluntarily and received no payment or other compensation for their time.

Interviewers were all experienced researchers in the domain of experimental investigative interviewing. Since rapport is not a singular concept, but rather comprises a cluster of behaviours which are variously understood and applied according to context, prior experience, and training, before conducting interviews for this research all underwent bespoke (designed for this research by the first author) training towards reducing variability of application. Training adopted a collaborative pedagogical approach and comprised (i) a 4-hour long classroom-based introduction to the rapport behaviours that were the subject of this research, including how and when they should be used during interviews; (ii) 2 × 4-hour long instruction and practice sessions using the VE and VR headsets; (iii) reading of theoretical and applied training materials produced for this research; (iii) practice interviews (eight in total, four in each environment) face-to-face and using the VR, which were digitally recorded to allow feedback and evaluation on each interview before moving to the next; and (iv) instruction on reflective research practice and critical self-evaluation of performance. Once researchers had attended the training sessions and completed the required competencies (consistent and correct application of the rapport behaviours as required by the protocols in at least two of the four practice interviews per environment), they were able to commence research interviews. In total, training for this research took between 3 and 4 days to complete.

Interview coding

Interviews were digitally audio and video recorded, transcribed verbatim, and coded for correct, erroneous (information relevant to the witnessed episode but described with error, e.g., describing a person's brown jacket, but stating that it was black instead of brown), or confabulated (reporting information that was not present in the film) information recalled. The position in the interview the information was recalled was coded (i.e., whether recalled in the free-recall or questioning phase). Items recalled were only scored once (i.e., repetitions were not scored irrespective of interview phase). Five interviews from each condition (20 in total) were randomly selected for recoding by an independent coder blind to the aims and hypotheses of the research but familiar with the method of scoring. Two-way mixed effects intraclass correlation coefficient (ICC) analysis testing for absolute agreement between coders for the overall amount of correct, erroneous, and confabulated recall were conducted. Mean estimations with 95% CI reveal very good interrater reliability for correct information, ICC = .993 (95% CI [0.982, 0.994]), errors, ICC = .954 (95% CI [0.888, 0.982]) and confabulations, ICC = .865 (95% CI [0.658, 0.946]).

The same sample of 20 interviews were coded by a further two independent coders blind to the aims and hypotheses of

the research for adherence to the interview protocol as a function of condition: that is, no rapport-building behaviours in the rapport-absent (control) conditions and presence of rapport-building behaviours in the rapport-present conditions (see Table 1). A scoring sheet was used where each of the behaviours were coded, ranging from 1 to 3 for each according to condition (e.g., 3 = *fully implemented the open-ended self-disclosure behaviour*, 2 = *partially implemented the open-ended questions behaviour*, 1 = *did not implement*) as a function of phase (e.g., see Nahouli et al., 2021). The rapport phase occurred only in the rapport-building condition, while the free-recall and questioning phases were common to all conditions. In the rapport phase, six rapport behaviours were coded (see Table 1), and in the free-recall and questioning phases, four rapport behaviours were coded. To score 1, the behaviour in question had to be absent. To score 2, the behaviour had to be present at least once but no more than twice. To score 3, the behaviour had to be present at least three times. Thus, each phase was awarded scores ranging from 6 to 18 for the rapport phase (in the rapport condition, only), and ranging from 4 to 12 for each of the free-recall and questioning phases.

Two-way mixed-effects ICC analysis testing for absolute agreement between coders for the six rapport-building behaviours expected to be present/absent in the rapport phase revealed good interrater reliability for each of the behaviours; open questions, ICC = .899 (95% CI [.593, .975]), offering non-personal information, ICC = .862 (95% CI [.443, .966]), making eye contact, ICC = .862 (95% CI [.443, .966]), nodding, ICC = .865 (95% CI [.498, .964]), referring to interviewee by name, ICC = 1.00 (95% CI [1.00, 1.00]) and thanking the interviewee, ICC = .757 (95% CI [.096, .935]).

Good interrater reliability was also found for the four rapport-building behaviours expected to be present/absent in the free-recall phase: eye contact, ICC = .938 (95% CI [.843, .975]), nodding, ICC = .883 (95% CI [.705, .954]), referring to interviewee by name, ICC = 1.00 (95% CI [1.00, 1.00]), and thanking the interviewee, ICC = 1.00 (95% CI [1.00, 1.00]); and questioning phase: making eye contact, ICC = .883 (95% CI [.705, .954]), nodding, ICC = .979 (95% CI [.948, .992]), referring to interviewee by name, ICC = 1.00 (95% CI [1.00, 1.00]), and thanking the interviewee, ICC = 1.00 (95% CI [1.00, 1.00]).

Rapport manipulation analysis

Means (*SD*s & 95% CIs) for rapport behaviours across phases common to all interview conditions as a function of environment and interview condition are displayed in Table 2.

The rapport-present main effect was nonsignificant for all four rapport-building behaviours across environments,

Table 2 Mean scores for presence/absence of rapport as a function of condition and environment, as a function of recall phase (1 = *not implemented*; 2 = *partially implemented*; 3 = *fully implemented*)

	Mean (SD) 95% CI	
	Free Recall	Questioning
VE Rapport Absent		
Looking/eye contact	1.16 (.37) 1.01; 1.32	1.16 (.36) 1.00; 1.31
Nodding	1.08 (.27) .97; 1.19	1.08 (.27) .97; 1.19
Name	1.00 (.00) 1.00; 1.00	1.04 (.20) .96; 1.12
Thank you	1.08 (.27) .97; 1.19	1.12 (.33) .98; 1.25
F-to-F Rapport Absent		
Looking/eye contact	1.16 (.38) 1.01; 1.31	1.17 (.37) 1.01; 1.31
Nodding	1.08 (.30) .96; 1.19	1.08 (.27) .97; 1.19
Name	1.04 (.20) .96; 1.12	1.04 (.20) .96; 1.12
Thank you	1.09 (.29) .97; 1.19	1.08 (.27) .96; 1.19
VE Rapport Present		
Looking/eye contact	2.80 (.50) 2.59; 3.01	2.72 (.54) 2.50; 2.94
Nodding	2.84 (.37) 2.65; 2.99	2.88 (.33) 2.74; 3.02
Name	2.84 (.47) 2.64; 3.04	2.80 (.51) 2.59; 3.01
Thank you	2.80 (.50) 2.59; 3.00	2.80 (.50) 2.59; 3.01
F-to-F Rapport Present		
Looking/eye contact	2.88 (.33) 2.74; 3.01	2.89 (.34) 2.74; 3.02
Nodding	2.88 (.34) 2.74; 2.99	2.88 (.33) 2.92; 3.03
Name	3.00 (.00) 3.00; 3.00	2.96 (.20) 2.88; 3.04
Thank you	3.00 (.00) 3.00; 3.00	2.96 (.21) 2.87; 3.04

Table 3 Mean scores for presence/absence of rapport-building behaviours as a function of environment and rapport across phases (1 = *not implemented*; 2 = *partially implemented*; 3 = *fully implemented*)

	Mean (SD) 95% CI	
	Free Recall	Questioning
Virtual Environment (VE)		
Looking/eye contact	1.98 (.98) 1.93. 2.03	2.00 (.98) 1.93. 2.07
Nodding	2.00 (1.10) 1.93, 2.07	1.98 (.98) 1.91, 2.05
Name	1.96 (.99) 1.92, 1.99	1.99 (1.00) 1.92, 2.03
Thank you	2.00 (.99) 1.93, 2.06	1.98 (.99) 1.93, 2.02
Face-to-Face (FtF)		
Looking/eye contact	2.00 (1.01) 1.93, 2.05	2.00 (1.01) 1.93, 2.06
Nodding	2.00 (.99) 1.03, 2.06	2.02 (.96) 1.95, 2.09
Name	2.00 (1.03) 1.92, 1.99	1.98 (.97) 1.92, 2.36
Thank you	1.99 (.97) 1.93, 2.07	1.96 (.98) 1.91, 2.01
Rapport Absent		
Looking/eye contact	1.02 (.14) .97, 1.07	1.06 (.24) .99, 1.13
Nodding	1.06 (.19) .99, 1.13	1.06 (.23) .99, 1.12
Name	1.00 (0.00) .96, 1.04	1.02 (.14) .96, 1.08
Thank you	1.07 (.24) .99, 1.12	1.00 (0.00) .95, 1.05
Rapport Present		
Looking/eye contact	2.96 (.20) 2.91, 3.01	2.94 (.24) 2.87, 3.01
Nodding	2.94 (.24) 2.87, 3.01	2.94 (.23) 2.87, 3.01
Name	2.96 (.20) 2.92, 3.00	2.94 (.20) 2.89, 2.98
Thank you	2.94 (.24) .96, 1.04	2.94 (.24) 2.88, 3.00

in both the free-recall, all Fs < 4.00, all ps > .059, and questioning phases, all Fs < 2.21, all ps > .144 revealing that all behaviours were similarly present across the two environments in both recall phases. Likewise, there were no significant differences across environments in the rapport-absent conditions for the four rapport-building behaviours in either the free-recall, all Fs < 1.00, all ps > .322, or questioning phases, all Fs < .214, all ps > .646, and so all rapport behaviours were similarly absent.

There were no significant differences across environment (VE and face-to-face) in the rapport phase of the rapport-present conditions for use of the six rapport behaviours applied in this phase: (i) open-ended questions (M_{VE} = 2.80, SD = .41; M_{FtF} = 2.84, SD = .37), (ii) offering information (M_{VE} = 2.96, SD = .20; M_{FtF} = 2.91, SD = .21), (iii) looking at interviewees when they speak (M_{VE} = 2.80, SD = .40; M_{FtF} = 2.92, SD = .28), (iv) using interviewee's name (M_{VE} = 2.88, SD = .33; M_{FtF} = 2.88, SD = .32), (v) nodding in acknowledgement when interviewees speak (M_{VE} = 2.84, SD = .37; M_{FtF} = 2.95, SD = .20), and (vi) thanking interviewees when they answer questions (M_{VE} = 2.84, SD = .31; M_{FtF} = 2.88, SD = .31), all Fs < 2.00, all ps > .164.

There was a significant main effect of rapport condition (present/absent) for all four rapport behaviours in the free-recall phase (common to all interviews), looking at

the interviewee/making eye contact when the interviewee speaks, $F(1, 96) = 3221.94$, $p < .001$, $\eta_p^2 = .91$, using the interviewee's name, $F(1, 96) = 5010.78$, $p < .001$, $\eta_p^2 = .94$, thanking the interviewee when they answered questions, $F(1, 96) = 1319.51$, $p < .001$, $\eta_p^2 = .993$, and nodding in acknowledgement when the interviewee spoke, $F(1, 96) = 1514.70$, $p < .001$, $\eta_p^2 = .94$. All behaviours occurred significantly more often in the rapport-present condition than in the rapport-absent condition. There were no significant main effects of environment, and the Environment × Rapport interactions were also nonsignificant, all Fs < 3.08, all ps > .082 (see Table 3). Similarly, in the questioning phase (common to all interviews) there was a significant main effect for all four rapport behaviours (Table 3), looking at the interviewee/making eye contact when they spoke, $F(1, 96) = 1514.07$ $p < .001$, $\eta_p^2 = .94$, using the interviewee's name, $F(1, 96) = 2353.02$, $p < .001$, $\eta_p^2 = .96$, thanking the interviewee, $F(1, 96) = 3225.94$, $p < .001$, $\eta_p^2 = .97$, and nodding in acknowledgement, $F(1, 96) = 1412.10$, $p < .001$, $\eta_p^2 = .92$.

All behaviours occurred significantly more often in the rapport condition than in the no-rapport condition. There were no significant main effects of environment, and the Environment × Rapport interactions were also nonsignificant, all Fs < 1.02, all ps > .315.

A random sample of five interviews conducted by each interviewer (25 interviews in total) was coded for adherence to the interview protocol phases by two independent raters using a scoring sheet (ranging from 3 = *fully implemented every phase* to 0 = *did not implement*). The rapport-present interviews comprised six phases (see Table 1), whereas the no-rapport interviews comprised five phases. Analysis revealed a substantial level of agreement between raters, Kappa = .921, *p* = .003. Interviewer adherence across phases revealed no significant differences as a function of interviewer for adherence to each phase, all *F*s < 3.211, *p* = > .217, and each interviewer applied each phase as a function of condition.

Results

Analysis approach

To investigate H^1 and H^2 a series of 2 (environment: face-to-face, virtual) × 2 (rapport: present, absent) ANOVAs were conducted. Global memory performance (performance across the duration of the interview) main effects and interactions were investigated using the number of correct, incorrect, and confabulated items recalled, and percentage accuracy. Performance as a function of retrieval phase was analysed to investigate the pattern of memory performance and locus of any significant global main effects and interactions. Finally, to investigate H^3, interviewee post interview feedback was analysed across conditions where appropriate, and responses to condition-specific questions. Guided by our additional research question, Environment × Rapport interactions were exploratory, allowing us to investigate the combined effects of rapport and retrieval environment. Global duration of interviews, duration of the two recall phases (combined), and the number of questions asked in the question phase of interviews were also analysed to fully explore the impact of environment and condition for applied audiences.

Global memory performance

Correct recall There were significant main effects of environment, $F(1, 96) = 17.814$, $p < .001$, $\eta_p^2 = .16$, and rapport, $F(1, 96) = 6.840$, $p = .010$, $\eta_p^2 = .07$, for correct recall. Participants interviewed in the VE recalled more correct information than those interviewed face-to-face, and when rapport was present participants recalled more correct information (see Table 4 for main effects). There was a significant Environment × Rapport interaction, $F(1, 96) = 6.638$, $p = .012$, $\eta_p^2 = .07$. When rapport was present, participants interviewed in the VE recalled more correct information, $p < .001$ (Table 5). All other interactions were nonsignificant.

Table 4 Main effects of rapport and environment (Means, *SD*s, and 95% CIs) on correct, incorrect and confabulated recall

	Correct	Incorrect	Confabs
	M (SD) 95% CI		
Environment			
Virtual Environment	72.94 (19.88)	6.44 (4.54)	.68 (0.95)
	68.33, 77.55	4.95, 7.93	0.23, 1.13
In-Person FtF	62.92 (14.02)	10.20 (6.76)	1.20 (2.13)
	58.31, 67.53	8.71, 11.69	.79, 1.69
Rapport			
Present	71.02 (18.16)	7.00 (4.11)	.64 (.95)
	66.68, 75.36	5.51, 8.49	.19, 1.09
Absent	62.94 (16.04)	9.64 (7.28)	1.24 (2.14)
	58.60, 67.28	8.09, 11.13	.79, 1.69

Incorrect recall There were significant main effects of environment, $F(1, 96) = 12.541$, $p < .001$, $\eta_p^2 = .12$, and rapport, $F(1, 96) = 6.183$, $p = .015$, $\eta_p^2 = .06$, for incorrect recall. Participants interviewed in the VE recalled fewer incorrect items of information than those interviewed in-person face-to-face (see Table 4). When rapport was present participants also recalled fewer incorrect items of information. There was a significant Environment × Rapport interaction, $F(1, 96) = 13.081$, $p < .001$, $\eta_p^2 = .12$ (see Table 5). When rapport was absent, participants interviewed FtF recalled significantly more incorrect items of information, $p < .001$. All other interactions were nonsignificant.

Confabulations There were nonsignificant main effects of environment and rapport, all *F*s < 3.52 and all *p*s > .064. There was a significant Environment × Rapport interaction, $F(1, 96) = 5.648$, $p = .019$, $\eta_p^2 = .56$. When rapport was absent, participants confabulated more during in-person face-to-face interviews, $p = .002$ (see Table 5). All other interactions were nonsignificant.

Percentage accuracy There were significant main effects of environment, $F(1, 96) = 21.069$, $p < .001$, $\eta_p^2 = .18$, and rapport, $F(1, 96) = 11.350$, $p = .001$, $\eta_p^2 = .11$, for percentage accuracy. Participants were more accurate in the VE ($M_{VE} = 91.23$, $SD = 3.11$, 95% CI [88.79, 93.66]) than in-person face-to-face ($M_{F2F} = 89.69$, $SD = 6.26$, 95% CI [87.26, 93.67]). They were also more accurate when rapport was present ($M_{rapport} = 90.46$, $SD = 4.95$, 95% CI [89.06, 91.87]) than when it was absent ($M_{no\ rapport} = 86.33$, $SD = 8.58$, 95% CI [83.89, 88.77]). The Environment × Rapport interaction was also significant, $F(1, 96) = 11.118$, $p = .001$, $\eta_p^2 = .10$. Participants were less accurate when interviewed in-person face-to-face when rapport was absent ($M_{F2F\ No\ rapport} = 81.48$, $SD = 7.99$, 95% CI [79.05, 83.91]) than those interviewed in-person face-to-face when rapport

Table 5 Rapport × Environment interactions (Means, *SD*s, and 95% CIs) for global correct, incorrect, and confabulations

	Correct	Incorrect	Confabs
M (SD) 95% CI			
Virtual Environment + Rapport	81.52 (19.48)	7.04 (3.67)	.76 (.91)
	75.39, 87.65	4.93, 9.15	.13, 1.40
FtF + Rapport	60.52 (7.93)	6.96 (4.61)	.52 (0.71)
	54.39, 66.65	4.85, 9.07	-.13, 1.15
Virtual Environment No Rapport	65.48 (17.16)	5.84 (5.31)	.60 (0.91)
	59.35, 71.61	3.73, 7.95	-.04, 1.24
FtF No Rapport	60.48 (14.75)	13.44 (7.05)	1.88 (2.80)
	59.35, 71.61	11.33, 15.54	1.25, 2.52

was present ($M_{F2F\ rapport}$ = 89.69, SD = 3.11, 95% CI [87.26, 92.13]) and those interviewed in the VE when rapport was present ($M_{VE\ rapport}$ = 91.23, SD = 6.12, 95% CI [88.80, 93.67]) and absent ($M_{VE\ No\ rapport}$ = 91.19, SD = 6.12, 95% CI [88.76, 93.63]), all *p*s < .001. All other interactions were nonsignificant.

Recall phase memory performance

Given the small mean confabulations, in analysing memory as a function of interview phase (free-recall and questioning) we collapsed the two types of errors (incorrect information and confabulations) to allow a more meaningful interpretation.

Free-recall phase

Correct recall There was a significant main effect of environment, $F(1, 96)$ = 13.81, $p < .001$, η_p^2 = .13. Participants interviewed in the VE recalled more correct items of information in the free-recall phase (M_{VE} = 41.96, SD = 13.32, 95% CI [39.04, 44.88]) than those interviewed in-person face-to-face (M_{F2F} = 34.22, SD = 7.14, 95% CI [26.79, 38.05]). The main effect of rapport was nonsignificant, F = 3.01, p = .082 ($M_{rapport}$ = 39.92, SD = 11.97; $M_{no\ rapport}$ = 36.26, SD = 10.45). The Environment × Rapport interaction was significant, $F(1, 96)$ = 4.18, p = .044, η_p^2 = .04. When rapport was present participants interviewed in the VE recalled more correct information in the free-recall phase ($M_{VE\ rapport}$ = 45.92, SD = 12.83, 95% CI [41.79, 50.05]) than those interviewed face-to-face ($M_{F2F\ rapport}$ = 33.92, SD = 7.26, 95% CI [29.79, 38.05]), $p < .001$. When rapport was absent, participants interviewed in the VE recalled more correct information ($M_{VE\ No\ rapport}$ = 38.00, SD = 12.85, 95% CI [33.87, 42.13]) than those interviewed face-to-face ($M_{F2F\ No\ rapport}$ = 34.52, SD = 7.16, 95% CI [30.87, 38.65]), p = .001.

Errors There were significant main effects of environment, $F(1, 96)$ = 18.23, $p < .001$, η_p^2 = .16, and rapport, $F(1,$

96) = 8.63, p = .004, η_p^2 = .08 for the number of errors in the free-recall. Participants interviewed in the VE made significantly fewer errors (M_{VE} = 1.92, SD = 2.44, 95% CI [1.20, 2.64]) than those in the in-person face-to-face condition (M_{F2F} = 4.10, SD = 3.18, 95% CI [3.83, 4.18]). Where rapport was present participants made significantly fewer errors ($M_{rapport}$ = 2.26, SD = 2.04, 95% CI [1.54, 2.98]) than when rapport was absent ($M_{No\ rapport}$ = 3.76, SD = 3.62, 95% CI [3.04, 4.48]). The Environment × Rapport interaction was significant, $F(1, 96)$ = 16.27, $p < .001$, η_p^2 = .15. When rapport was absent, participants interviewed in-person face-to-face made more errors ($M_{F2F\ No\ rapport}$ = 5.88, SD = 3.14, 95% CI [4.87, 6.89]) than those interviewed in the VE ($M_{VE\ No\ rapport}$ = 1.64, SD = 1.60, 95% CI [.67, 2.65]), p = .001, and when rapport was present participants interviewed in-person face-to-face ($M_{F2F\ rapport}$ = 2.32, SD = 2.06, 95% CI [1.31, 3.33]) made more errors than this interviewed in the VE ($M_{VE\ rapport}$ = 1.64, SD = 1.08, 95% CI [1.89, 3.21]), $p < .001$.

Questioning phase

Correct recall There were significant main effects of environment and rapport on the amount of correct information recalled in the questioning phase, $F(1, 96)$ = 7.51, p = .007, η_p^2 = .07, and $F(1, 96)$ = 4.42, p = .038, η_p^2 = .04, respectively. Participants interviewed in the VE recalled more correct information (M_{VE} = 31.54, SD = 11.73, 95% CI [28.72, 34.36]) than those in the in-person face-to-face condition (M_{F2F} = 26.04, SD = 8.76, 95% CI [23.22, 28.86]). Participants also recalled more correct information when rapport was present ($M_{rapport}$ = 30.09, SD = 12.30, 95% CI [28.08, 33.72]) than when it was absent ($M_{No\ rapport}$ = 26.68, SD = 8.32, 95% CI [23.86, 29.50]). The Environment × Rapport interaction was nonsignificant for the questioning phase, F = 3.78, p = .055.

Errors The main effects of environment, F = 3.86, p = .052 (M_{F2F} = 7.10 SD = 5.98, 95% CI [5.76, 8.44]; M_{VE} = 5.22 SD = 3.60, 95% CI [5.76, 8.44]), and rapport, F = 2.52, p

= .116, were nonsignificant for the number of errors in the questioning phase ($M_{Rapport}$ = 5.40 SD = 3.49 95% CI [5.76, 8.44]; $M_{No\ rapport}$ = 6.92 SD = 6.09, 95% CI [5.76, 8.44]). However, the Environment × Rapport interaction was significant, $F(1, 96)$ = 5.67, p = .019, η_p^2 = .06. Participants reported more errors in the in-person face-to-face condition when rapport was absent ($M_{F2F\ no\ rapport}$ = 9.00 SD = 7.11, 95% CI [7.10, 10.90]) than in the VE when rapport was absent ($M_{VE\ no\ rapport}$ = 4.84 SD = 4.03, 95% CI [2.94, 6.74]), p = .004. When rapport was present, there were no significant differences between participants in the in-person face-to-face ($M_{F2F\ rapport}$ = 5.20 SD = 3.85, 95% CI [2.94, 6.74]) and VE conditions ($M_{VE\ rapport}$ = 5.60 SD = 3.16, 95% CI [3.70, 7.50]).

Interview duration

Global duration As one might expect due to the additional rapport phase, there was a significant main effect of condition on interview duration (from start to finish including all interview phases), $F(1, 96)$ = 108.22, p = <. 001, η^2 = .53. Globally, rapport-building interviews were significantly longer (M = 44.96 mins, SD = 5.12, 95% CI [42.60, 46.17]) than the no-rapport-building interviews (M = 31.17 mins, SD = 9.15, 95% CI [29.38, 32.95]). The main effect of environment was nonsignificant, $F(1, 96)$ = 1.13, p = . 291, as was the Environment × Condition interaction, $F(1, 96)$ = .02, p = . 887.

Recall phase duration Similarly, the duration of the free-recall and question phases combined, revealed a significant main effect of condition, $F(1, 96)$ = 73.17, p <. 001, η^2 = .43. As expected, rapport-building interviews were longer across the combined recall phase (M = 32.71 mins, SD = 5.56, 95% CI [31.33, 34.10]) than the no rapport interviews (M = 24.29 mins, SD = 4.09, 95% CI [22.91, 25.67]). The main effect of environment was nonsignificant, $F(1, 96)$ = .35, p = . 553, as was the Environment × Condition interaction, $F(1, 96)$ = .09, p = . 759.

Probing tell, explain, describe (TED) questions

The main effect of rapport ($M_{rapport}$ = 11.52, SD = 1.76, $M_{no\ rapport}$ = 10.74, SD = 2.16), was nonsignificant, F = 3.822, p = .053, as was the main effect of environment (M_{VE} = 11.16, SD = 2.08, 95% CI [10.60, 11.72]; M_{F2F} = 11.10, SD = 1.94, 95% CI [10.54, 11.66]), F = .03, p = .881. The Environment × Rapport interaction for the number of questions asked was also nonsignificant, F = .003, p = .961.

Post interview feedback

Feedback means (SDs and 95% Cis) are shown in Table 6. There was a significant main effect of rapport, $F(1, 96)$ = 16.86, p < .001, η_p^2 = .15, and a significant Rapport × Environment interaction, $F(1, 96)$ = 5.590, p = .020, η_p^2 = .06, for how easy/difficult participants had found it to remember what they had seen. Participants in the rapport-present condition reported finding it easier to remember than those in the no-rapport condition. Participants in the no rapport VE condition reported finding the recall task more difficult than those in the no rapport face-to-face condition. The effect of environment was nonsignificant, F = 2.17, p = .109.

There were significant main effects of rapport, $F(1, 96)$ = 42.09, p = < .001, η_p^2 = .30, and environment, $F(1, 96)$ = 35.31, p < .001, η_p^2 = .27, for confidence that recall was correct. Participants in the rapport-present condition reported feeling more confident their recall was correct than those in the no-rapport condition. Likewise, participants in the VE condition reported feeling more confident they were correct. The Environment × Rapport interaction was also nonsignificant, F = 3.57, p = .062.

There were no significant main effects nor interactions for confidence ratings regarding errors, all Fs < 1.17, all p > .281. Participants were generally undecided (50%) as to whether they had made any errors or not. There were significant main effects of environment, $F(1, 96)$ = 155.83, p < .001, η_p^2 = .62, and rapport, $F(1, 96)$ = 5.21, p = .025, η_p^2 = .05, for how comfortable participants felt during the interviews. Participants interviewed in the VE reported feeling more comfortable throughout the interview than those interviewed face-to-face, and participants in the rapport condition reported feeling more comfortable than those in the no-rapport condition, $F(1, 96)$ = 155.83, p < .001, η_p^2 = .62. The Environment × Rapport interaction was nonsignificant, F = .162, p = .688.

There were significant main effects of environment, $F(1, 96)$ = 57.28, p < .001, η_p^2 = .37, and rapport, $F(1, 96)$ = 5.71, p = .019, η_p^2 = .07, for how easy/difficult it was for participants to tell the interviewer they could not remember. Participants in the VE found it easier than those in the face-to-face environment, and participants in the no-rapport condition found it more difficult to say they could not remember. There was a significant Environment × Rapport interaction, $F(1, 96)$ = 7.78, p = .006, η_p^2 = .08. Participants in the face-to-face + rapport condition found it more difficult to say they could not remember than those in the face-to-face no-rapport condition, and participants in both VE + rapport and VE no-rapport conditions found it significantly less difficult than those in the face-to-face + rapport and face-to-face no-rapport conditions, p = .002

There were significant main effects of environment, $F(1, 96)$ = 19.27, p < .001, η_p^2 = .18, and rapport, $F(1, 96)$ =

Table 6 Post interview feedback main effects of environment and rapport, and interaction means (*SD*s & 95% CI)

	Mean (SD) 95% CI							
	Rapport	No Rapport	VE	F-to-F	VE + Rapport	VE No Rapport	F-to-F. + Rapport	F-to-F No Rapport
Easy/Difficult to remember (1 = very easy; 5 = very hard)	2.26 (.75) 2.03, 2.49	2.92 (.90)**. 2.69, 3.15	2.72 (.97) 2.49, 2.95	2.46 (.79) 2.23, 2.69	2.20 (.71) 1.88, 2.52	3.24 (.93)** 2.91, 3.56	2.32 (.80) 2.00, 2.64	2.60 (.76) 2.81, 2.92
Confident correct (1 = not at all; 5 = extremely)	3.58 (.81)** 3.37, 3.79	2.66 (.92) 2.52, 2.87	3.54 (.81)**. 3.33, 3.75	2.66 (.94) 2.52, 2.76	3.88 (.78) 3.59, 4.17	3.20 (.76) 2.90, 3.94	3.28 (.74) 2.99, 3.57	2.04 (.68) 1.75, 2.33
Confident made no errors (1 = extremely; 5 not at all)	3.10 (.91) 2.84, 3.36	2.94 (.94) 3.68, 3.20	2.94 (.93) 2.68, 3.12	3.10 (.90) 2.84, 3.40	3.12 (.93) 2.75, 3.49	2.76 (.93) 2.39. 3.13	3.08 (.91) 2.71, 3.45	3.12 (.93) 2.75, 3.49
Comfortable (1 = extremely; 5 not at all)	2.18 (1.17)**. 1.97, 2.39	2.52 (1.21). 2.31, 2.73	1.42 (.58)**. 1.21, 1.63	3.28 (.90) 3.07, 3.49	1.28 (.54) .98, 1.58	1.56 (.58) 1.26, 1.86	3.08 (.91) 2.78, 3.38	3.48 (.87) 3.18, 3.78
Say I can't remember (1= difficult; 5 easy)	3.04 (1.51). 2.76, 3.32	3.52 (1.10)* 3.24, 3.80	4.04 (1.02)**. 3.76, 4.32	2.52 (1.09). 2.24, 2. 80	4.08 (1.22). 3.68, 4.48	4.00 (.82) 3.60, 4.40	2.00 (.96)*. 1.60, 2.40	3.04 (.98)* 2.64, 3.44
Friendly (1 = very; 5 = not at all)	2.00 (.95)**. 1.72, 2.28	2.90 (1.27). 2.63, 3.18	2.04 (1.01)**. 1.77, 2.32	2.90 (1.25). 2.63, 3.18	1.92 (.99) 1.53, 2.51	2.16 (1.02)** 1.77, 2.55	2.08 (.91) 1.69, 2.47	3.72 (.98) 3.33, 4.11

* *p* < .05

** *p* < .001

23.03, $p < .001$, $\eta_p^2 = .19$, for ratings of how friendly participants found the interviewer. Participants in the VE found the interviewer more friendly than those in the face-to-face condition, and participants in the rapport condition found the interviewer more friendly than those in the no-rapport condition. A significant Environment × Rapport interaction also emerged, $F(1, 96) = 12.77$, $p < .001$, $\eta_p^2 = .12$. Participants in the VE no rapport found the interviewer more friendly than those in the no rapport face-to-face rapport condition, $p = .001$.

Participants interviewed in the VE were asked four additional questions. Eight (16%) stated they had used a virtual reality (VR) headset before (yes/no) and 42 (84%) stated they had not. Participants were asked how easy/difficult they found it to use the headset. Overall participants reported finding the headset extremely/somewhat easy to use ($M = 1.72$, $SD = .83$) with no significant difference between the rapport-present ($M = 1.84$, $SD = .99$) and rapport-absent conditions ($M = 1.60$, $SD = .67$), $F = 1.36$, $p = .314$. When asked how they generally liked/disliked being interviewed in a VE, overall participants reported somewhat liking the environment ($M = 2.02$, $SD = .96$) with no significant difference between the rapport-present ($M = 1.96$, $SD = .90$) and rapport-absent conditions ($M = 2.08$, SD $= 1.04$), $F = .19$, $p = .663$. Simple linear regression revealed that having used a VR headset before was not a significant predictor of ratings of ease of use nor liking of the VE environment, $R^2 = .047$, $F = 1.15$, $p = .372$. Finally, participants reported the headset to be very comfortable to wear ($M = 1.62$, $SD = .71$).

Discussion

Theoretical and evidence-based witness interviewing techniques typically champion rapport-building to reduce some of the social demands of recalling a crime event, thereby potentially increasing cognitive capacity for remembering. Cognitive and social benefits have also emerged in remote interview contexts with reduced anxiety and social pressure contributing to improved eyewitness performance. To date, as far as we are aware no research has investigated the combined impact of interview context and rapport-building

behaviours. Here, we investigated episodic memory in mock-eyewitness interviews conducted in virtual environments (VE) and in-person face-to-face (FtF), where rapport-building behaviours were either present or absent.

To summarise, participants interviewed in the VE demonstrated superior memory performance to those interviewed FtF, recalling an average of 15% more correct information, reporting more than 50% fewer erroneous details and over 40% fewer confabulations. Further, irrespective of environment, participants recalled more episodic information when rapport was present. However, the VE superiority effect was apparently augmented by the presence of rapport-building behaviours, since participants in the VE + rapport outperformed participants in all other conditions suggesting the benefits of each manipulation were complimentary. As one would expect both the global duration and combined recall phase duration of rapport-present interviews were significantly longer than when rapport was absent. Analysis of the combined recall phase during which participants were retrieving and verbalising episodic information revealed they were 30% longer in rapport-present interviews. However, the number of probing questions asked in the question phase that immediately follows the initial free recall did not significantly differ as a function of rapport, potentially indicating cognitive benefits in terms of supporting cognitive effort whereby responses to questions were more detailed and that the information was accurate since there was no increase in errors and confabulations.

Participants interviewed in the VE reported more correct information, fewer errors and with greater accuracy. Accordingly, our findings support H[1] and are similar to the results of research conducted by others (e.g., Bethel et al., 2013; Fängström et al., 2017; Hamilton et al., 2017; Nash et al., 2014; Taylor & Dando, 2018). However, our findings add to the emerging literature on cognition in VEs where information gathering is a primary goal (e.g., Baccon et al., 2019; Hope et al., 2011; Nash et al., 2014; Nash et al., 2020; Sun, 2014). The importance of social context is increasingly recognized in applied cognition research (Fisher et al., 2011; Powell et al., 2005; Taylor & Dando, 2018). Indeed, the social cognition literature concerning memory performance when social demand is controlled offers several potential explanations for our pattern of results (e.g., Vredeveldt et al., 2011; Wagstaff et al., 2011). Physical co-presence can impose dual task demands, reducing resources available for effortful remembering (Koutstaal et al., 2001; Vredeveldt et al., 2018; Vredeveldt et al., 2011). Monitoring of social, physical and linguistic cues while simultaneously recalling episodic information has been found to negatively impact retrieval and control processes Koriat & Goldsmith, 1994, 1996; Shapira & Pansky, 2019).

In a VE, dual task demands may be reduced since parties are not physically co-present. Rather, each is represented by an avatar, and they communicate as such. Hence, the social environment may be less demanding. Nonetheless, VEs allow an immersive experience, supporting natural behaviours and effective communication (Lee & Marsella, 2006; Shardaet al., 2006). Our feedback reveals participants interviewed in the VE reported reduced social demands, potentially allowing improved cognitive control. Cognitive control supports top-down resource allocation to goal-relevant tasks, here conscious recall (e.g., Braver et al., 2007; Kiyonaga et al., 2012; Savine et al., 2010), which has been found to enhance performance in cognitively complex tasks such as episodic retrieval (e.g., Botvinick et al., 2001; Greene et al., 2004; Hammond & Summers, 1972; Rondeel et al., 2015). Indeed, despite differences in recall duration, that there was parity across conditions for the number of probing (TED) questions asked adds weight to the importance of environment for supporting cognitive effort and the benefits of doing so for improved performance.

Equally, the VE might have promoted memory performance by potentially reducing feelings of anxiety often associated with traditional in-person face-to-face interactions (Davis & Bottoms, 2002; Fisher & Geiselman, 1992). Theories suggest that anxiety can compete for cognitive resources (e.g., Eysenck & Calvo, 1992; Eysenck et al., 2007). Reduced anxiety at retrieval releases cognitive resources for memory search with potential for improving memory output. In this study, VE participants reported feeling more comfortable during the interview compared to the FtF participants, which suggests a more relaxed experience, perhaps. Nevertheless, neither actual nor perceived anxiety was directly measured, and so future research could investigate anxiety and trauma responses in remote interviewing settings.

In line with predictions on the benefits of rapport for leveraging cooperation and eliciting information (e.g., Abbe & Brandon, 2014; K. Collins & Carthy, 2019; Gabbert et al., 2020; Nahouli et al., 2021), our cluster of rapport behaviours were well received and resulted in quantifiable benefits (more information & fewer errors), providing support for H[2]. Where rapport was present in the free recall, fewer errors were made, and more correct information items were reported. In follow-on probing (TED) questioning, additional correct information was reported without concomitant increases in errors. Questioning is vital for gathering additional fine-grained information (Ministry of Justice, 2011). However, this additional information is often accompanied by errors, a consistently reported pattern in adults and children (Dando, 2013; Dando et al., 2009; Köhnken et al., 1999; Mattison et al., 2015; Memon et al., 2010; Milne & Bull, 2002; Milne et al., 2019) and so understanding which types of interviewing technique or interviewer behaviours have potential to mitigate errors is important.

Two possible explanations emerge for why rapport-building might mitigate errors during probing (TED) questioning. First, feedback revealed participants were more comfortable and found it easier to say when they couldn't remember. This is crucial, since errors increase when witnesses feel pressure (real or perceived) to provide answers even when unsure (Scoboria & Fisico, 2013; see also Ceci & Bruck, 1993). Second, the rapport superiority effect may have carried over from the preceding free-recall phase. Reduced errors from the offset offer some protection as the interview progresses, since interviewees are not then questioned about information initially provided, which unbeknown to them may have been erroneous—where the free-recall is highly accurate, it follows that the questioning phase may be more accurate, also.

The benefit of external task support for improved episodic recall is clear (e.g., Dando et al., 2020; Fisher & Geisleman, 1992; Hope et al., 2014; Mattison et al., 2015; Smith & Vela, 1992). Here, rapport-building behaviours offered support in line with this literature, assuaging the social demands of an interview to support goal-directed allocation of resources (Dando, 2013; Mather & Knight, 2005; Vredeveldt et al., 2018; Vredeveldt et al., 2011; Wagstaff et al., 2011). Saying "I do not know" or "I can't remember" allows witnesses to withhold information they are less confident about (see Koriat & Goldsmith, 1994). Low confidence responses are typically less accurate than high confidence responses (e.g., Evans & Fisher, 2011; Wixted et al., 2018), although not always (e.g., Berkowitz et al., 2020; Sauer et al., 2019). Feedback revealed participants in the rapport condition were more confident in their memory and were more comfortable saying they did not know/could not remember.

Finally, participants in the VE + rapport condition outperformed all others. While the standalone benefits of rapport-building and the VE are apparent, our performance and feedback results indicate these benefits were additive in this condition. The VE apparently reducing feelings of anxiety associated with traditional in-person FtF interactions alongside rapport-building behaviours, which feedback indicated had lowered the cognitive task demands. We did not, however, observe a similar pattern of interaction results in the FtF + rapport condition, thereby adding to the literature concerning the potential the benefits of VEs as interviewing spaces (e.g., Mousas et al., 2018; Saarijärvi & Bratt, 2021; Sutherland, 2020) and the impact of environment on complex cognition. The locus of improved performance in the VE + rapport condition was the free recall, where 20% to 35% more correct information was reported than in the rapport-absent face-to-face and rapport-absent VE conditions.

Correct recall interactions were nonsignificant in the follow-on questioning phase. In contrast, errors were high in face-to-face rapport-absent interviews, an increase of over 100% compared to the VE rapport-absent condition. The importance of rapport irrespective of environment is clear, but in face-to-face contexts rapport appears particularly important for mitigating errors and increasing information gain. Our findings add to the importance of rapport (e.g., R. Collins et al., 2002; Nahouli et al., 2021; Risan et al., 2016) for interpersonal communication (e.g., Abbe & Brandon, 2014; Alison et al., 2013; Gabbert et al., 2021) and offer novel insights into the use of rapport in VEs for investigative purposes. As reported elsewhere, we too found rapport could be built between agents in VE and that agent-generated rapport-building was effective (e.g., Gratch et al., 2006; Hale & Antonia, 2016; Herrera et al., 2020; Rotman & Wu, 2015).

Limitations should be noted. Mock witness paradigms do not precisely replicate the experiences of real eyewitnesses. Nonetheless, some social and cognitive demands were present. Participants were recruited from the general population and were unfamiliar with eyewitness research but were made aware that memory was important and would be assessed. This demand characteristic is present with real witnesses who understand the importance of their memory performance (Fisher et al., 2017; Geiselman & Fisher, 2014; Hoogesteyn et al., 2020) and the need to provide detailed information. Further limitations stem from our operationalisation of a series of basic techniques, thus reducing a multifaceted social behaviour to individual components. It is likely that the value of rapport is far more. A priori power analysis (Faul et al., 2007) revealed our sample size was more than adequate to detect large effects but would not be powerful enough to detect small effects. Future research might consider larger sample sizes towards a more nuanced understanding, although the impact of small effect sizes for applied research is currently the subject of discussion (see Götz et al., 2022; Primbs et al., 2022). We did not consider the impact of individual rapport behaviours and neither did we collect formal interviewer feedback in terms of perceived challenges and benefits of interviewing in a VE, for example.

Despite limitations common to most applied research of this nature, our findings advance understanding of the positive impact of basic rapport-building behaviours *per se*, and as far as we are aware is the first to have highlighted the impact of rapport-building in avatar-to-avatar investigative witness interview contexts. Virtual reality technologies have significant, yet-to-be-fully realised potential to change and improve professional practice in terms of apparently seamlessly supporting prosocial compliance and improving associated cognitions. Increased availability of VR headsets allows people to easily communicate in VEs using accessible platforms. Most participants (+80%) had never used VR headsets but reported them easy to use and were open to being interviewed in VEs. However, availability and accessibility of hardware and software and end-user acceptability requires further attention, although pre COVID-19 government statistics reveal 91% of UK adults already use web-based platforms (Office of National Statistics, 2019). Since

the COVID-19 pandemic, digital adoption has taken a quantum leap, changing the way that organisations do business, including police and government bodies (e.g., national crime agency) concerned with security. Accordingly, cognition in VEs must be further investigated, and research is urgently needed to better understand rapport in a diverse range of investigative contexts.

Nonetheless, this research does provide much needed insight into the importance of task support for complex cognition in applied settings in terms of considering both retrieval environment and managing prosocial behaviours. Our results illuminate the importance of a cluster of basic prosocial behaviours used in combination, and as such offer interviewing professionals additional "tools" towards improved outcomes, and a way of practicing and honing their rapport-building and interviewing skills which seem very likely to port across to more traditional in-person face-to-face contexts.

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