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# Contested Staring: Issues and the use of mutual gaze as an on-line measure of social presence

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## Abstract

*Despite many of the current social presence measures relying heavily on subjective post-test questionnaires, some researchers have identified the value of using on-line, behavioural measures. Gaze, and specifically mutual gaze, is known to be related to social perceptions of an interlocutor, as well as facilitating task performance during an interaction [1, 2, 17]. Second Life allows for the investigation of task-based interaction in a highly controllable social environment, whilst simultaneously allowing measurement of eye movements (using a head-mounted eye-tracker). A paradigm for measuring eye movements of a user during interaction with an avatar or agent is presented. The potential for using this paradigm to investigate the use of mutual gaze as an on-line measure of social presence is discussed.*

**Keywords**---eye movements, mutual gaze, social presence, Second Life.

## 1. Introduction

This paper explores the potential of using Second Life as a platform to study social interaction, specifically the relationship between mutual gaze, social presence perceptions and task performance. There is research suggesting that mutual gaze plays an important role in the social perceptions of a conversational partner; this paper presents a paradigm to test this assertion. It begins with a review of relevant literature with the presentation of the paradigm that allows such an investigation to be carried out. Two previous studies are presented in which the paradigm was used to analyse user eye movements during task-based interactions in Second Life. A proposal for a new experiment to investigate the relationship between mutual gaze, social presence and task performance is then presented.

## 2. Social presence

Social presence (also sometimes known as co-presence) is an area of rapidly growing interest, with many definitions and measures having been postulated over recent years. For example, the terms 'social presence' and 'co-presence' have been known to be used interchangeably [1, 2], although some

maintain that social presence is made up of several dimensions. One such dimension is co-presence - the feeling that you are not alone [3]. Nowak [4] states that measuring presence (co-presence, social presence and presence as transportation in this case) gives a measure of the usability and an overall evaluation of a communication interface. A high level of presence is not experienced when a user is aware that the experience is mediated [5]. Extrapolating from this, social presence can be defined as a measure of how similar the experience of a mediated interaction with an avatar or agent is to that during a face-to-face interaction (the most socially present situation) in terms of perceptions of and behaviour towards an interlocutor. A high level of social presence during a mediated communication would elicit similar perceptions and behaviours as a face-to-face interaction would. By defining social presence as such, it becomes clear why it should be quantified and measured. Computer- and video-mediated interactions have become commonplace, and if the ideal is a face-to-face interaction then it is important to qualify and quantify what, in a mediated communication, should be optimised in order to make the interaction as successful and productive as possible. Much of the current social presence research relies heavily on participants responding to questionnaires, designed to measure the dimensions of social presence. From early work [6] to the more recent [3, 7-9], the vast majority of these questionnaires are administered post-interaction. The Social Presence in Gaming Questionnaire (SPGQ), for example, was developed to identify and measure the experience of social presence during digital gaming [8].

The original items were developed from a combination of interviews in focus groups and an existing social presence questionnaire, the Networked Minds Measure of Social Presence [3]. Validation of the resulting items was found to consist of 3 main factors: (1) psychological involvement – empathy; (2) psychological involvement – negative feelings and (3) behavioural involvement. The first factor included 7 items, such as I felt connected to the other(s) and I found it enjoyable to be with the other(s). The second factor included 6 items, such as The other tended to ignore me and I felt jealous of the other. Finally, the behavioural involvement factor contained 8 items, such as My actions depended on the other’s actions and I paid close attention to the other. The responses were on a 5-point intensity scale, ranging from “slightly” to “extremely”.

One of the potential issues about using post-test questionnaires such as the SPGQ, is that they have to be administered post-interaction. This means that users have already removed themselves from the interaction and have therefore become more aware of the computer mediating them. As soon as the interaction ends, the memory of that interaction will begin to fade. This will hold especially true if the respondent has exited the virtual environment in which the interaction occurred, as well as having finished communicating. As such, recall after the event may not totally reflect the feelings and thoughts that an individual has experienced during an interaction.

Bailenson and colleagues made a direct comparison between subjective (self-report) and behavioural measures of co-presence [10]. They measured the interpersonal distance between a participant and either an embodied tutoring agent or an unfamiliar embodied agent while the user was walking through an IVE. They found that more space was given to the embodied tutor than the unfamiliar agent. Self-report measures, however, revealed no difference between the subjective reactions to the tutor and the unfamiliar agent. It was suggested that behavioural, non-verbal, measurements may be advantageous, as compared with self-report questionnaires, in capturing the experience of co-presence, and how an embodied agent influences the behaviour of a user. The authors further suggest that behavioural, in conjunction with other measures, would be advantageous to the study of presence. The ideal would appear to be a subconscious behavioural measure, as opposed to a conscious one, as this could capture reactions to, and behaviours towards, a conversational partner as they unfold.

In another study, Bailenson and colleagues manipulated the gaze of virtual humans as participants

interacted with them within an immersive virtual environment [11]. Additionally, they varied the purported agency of the virtual human (i.e. whether the participant thought they were interacting with another human or with a computer). There were 2 gaze conditions; in the high-level gaze condition the participant was “engaged in mutual gaze” and in the low-level gaze condition the virtual human had its eyes closed and the head did not turn. More inter-personal distance was maintained between the users and the fronts of virtual humans than the backs. Participants left more space between themselves and agents in the high gaze condition. They also gave agents in this condition higher social presence ratings. This suggests that mutual gaze plays an important role in establishing social presence. One issue here is whether it is actually possible for an agent to “engage [the participant] in mutual gaze” due to the implicitly mutual nature of mutual gaze. Additionally, the two gaze conditions in this study seem to be extreme, neither of them approximating particularly well to natural human behaviour during an interaction. It could be suggested, therefore, that an optimum amount of gaze by an agent/avatar should be established, so that mutual gaze between the dyad, as well as social perceptions of an interlocutor, can be maximised. Here, again, the authors suggest that the addition of behavioural measures, specifically mutual gaze, may be a more sensitive measure of social presence than using only questionnaires. In terms of an experimental design, manipulating the level of social influence that the virtual human has over the user, whilst maintaining the consistency of all other sensory information is an ideal way of manipulating how socially present the virtual human appears to the user. From this, it may be possible to establish the validity of self-report measures of social presence.

If, as discussed by Bailenson and colleagues [10, 11], an ideal measure of social presence would utilise conscious, self-report and behavioural measures, then a questionnaire alone may not tell the entire story. It appears, therefore, that an initial validation of a self-report measure of social presence should be compared with, and supplemented by, another behavioural measure. As established by Bailenson et al. [11], an important measure of behaviour that is related to social interaction is that of mutual gaze. It is to this that we now turn.

### 3. Mutual gaze

Faces, and in particular eyes, tend to attract preferential attention in visual scenes. Castelhana and colleagues, for example, found that participants were

highly likely to fixate an actor's face in a photograph [12]. They also found that they were likely to fixate the actor's focus of attention (i.e. engage in joint attention) within the scene. Other research has established that people fixate eyes preferentially within a visual scene in order to encode information, or for the purposes of recognition [13]. Klin and colleagues studied the eye movements of autistic and normal individuals during viewing of films [14]. They found that autistic individuals tend to fixate the mouths of actors more than the eyes, which they imply is the expected viewing behaviour of normal individuals.

Mutual gaze, or eye contact, is a fundamental aspect of social interaction. Kendon examined some of the functions of gaze direction during social interaction [15]. He divided them into aspects related to social accessibility – an indication of a willingness to engage in, and commitment to continue, an interaction – and functional purposes – changing gaze direction to signal to another person what you're referring to. Mutual gaze has also been associated with facilitated task performance. Fry and Smith found that increased eye contact resulted in better task performance on a digit encoding task [16]. Fullwood and Doherty-Sneddon discovered that more looking by a confederate at the camera during a video presentation maximised the subsequent recall by the viewer [17]. If mutual gaze does, indeed, facilitate task performance, it would be pertinent to find out how to maximise the amount of mutual gaze between a conversational pair (dyad). Fry and Smith merely state that, "Eye contact was manipulated" during their experiment, with an instruction giver giving her conversational partner either "as much eye contact as possible" or "as little eye contact as possible", depending on the condition (p2). As previously mentioned, one of the fundamental aspects of mutual gaze is that it is a joint action – one cannot independently engage in mutual gaze, and therefore cannot give (or be given) mutual gaze, as it is an inherently mutual activity. Further exploration into how much gaze by one conversational partner at another maximises mutual gaze, and consequently task performance, should be carried out.

Research into mutual gaze can be divided into 3 types: that in relation to face-to-face communication, video-mediated communication (VMC) and computer-mediated communication (CMC). Within these areas, the definitions and measurements of mutual gaze have been diverse. Argyle and Dean aimed to outline the empirical determinants, psychological processes and functions of mutual gaze in face-to-face interactions [18]. The authors proposed that there is a need for equilibrium between various behaviours in social interaction, and that by increasing spatial proximity between two individuals the

amount of eye contact between them will decrease. They observed 2 people in conversation, one of whom was a confederate who gazed continuously at the other conversational partner (the participant), thus ensuring that the amount of eye contact was entirely under the participant's control. The confederate and participants' chairs were placed at varying distances from each other and the amount of eye contact during a 3-minute conversation was judged by an observer at a distance. They found that reducing eye contact makes greater proximity possible and that greater proximity reduces eye contact between two individuals.

Monk and Gale define mutual gaze as "knowing whether someone is looking at you" [19]. They looked at the benefits of having access to mutual gaze and full gaze awareness, compared to audio alone during VMC. Full gaze awareness was defined as the "ability to gauge the current object of someone else's visual attention". They found that, in terms of the efficiency of the conversation, full gaze awareness reduced the need for the use of verbal language, and that it was far superior in this respect to mutual gaze alone. One of the issues with this study is that access to mutual gaze during VMC could only be achieved by using a video tunnel set-up, due to the discrepancy between the camera position and the image of the other person's eyes; VMC does not usually support mutual gaze. Due to the importance of the functional and social benefits, access to mutual gaze as well as full gaze awareness should, where possible, be included in an interface, thus maximising access to nonverbal cues during an interaction. The authors, however, were unable to report on the benefits of having access to mutual gaze and full gaze awareness concurrently. This presents a problem since it would, in Monk and Gale's paradigm, require that extra windows be open to the viewer, resulting in crowded screen space and a requirement for attention shifts between the windows. This would presumably reduce the user's experience of social presence. This study highlights the importance of developing a platform that supports mutual gaze, as well as some level of full gaze awareness in a fashion that will reduce the user's awareness that the interaction is mediated, rather than face-to-face.

Turning to CMC, in a contemporary adaptation of Argyle's Equilibrium Theory paradigm [18], Bailenson and colleagues investigated users' behaviour during a task-based interaction with an agent in an immersive virtual environment (IVE) [20]. They found that when the agent stared at them females, but not males, maintained more interpersonal distance between themselves and the agent. They also found that more space was maintained

between all participants and the agent than a non-human-like object. This suggests that there is some aspect of being stared at that has the ability to alter an individual's behaviour.

It has been assumed that staring by one conversational partner at another will maximise mutual gaze between the pair [11, 16, 18, 20]. In fact, Bailenson and colleagues even go so far as suggesting that the staring agent "engaged them in eye contact". It could be suggested that the staring is neither behaviourally nor socially realistic, and that this pattern of looking may affect not only the perceptions of an agent and the performance in any task that is being carried out, but also the amount of mutual gaze in which an individual is willing to engage. As Kendon reports, "To be subjected to the continual gaze of another is a very unnerving experience, for to be the object of another's attention is to be vulnerable to him"[15]. In terms of perceptions of an agent, it has been discovered that perceptions of co-presence are lowest when there is a large mismatch between the appearance and behavioural realism of an agent [2]. If constant looking by an agent is not behaviourally realistic (it may look as if there is some malfunction, since it is not how one would expect a human to behave during an interaction), then how will this affect the perception of it? And if being stared at is, indeed, an uncomfortable position to be in, how will this affect how much an individual will be willing to return the gaze? It would therefore be of interest to discover whether constant gaze by an agent does, in fact, maximise mutual gaze, as well as how this constant gaze affects the perceived social presence of an agent. One particular IVE that may offer an opportunity to study both mutual gaze and social presence is Second Life.

#### 4. Second Life and Social Interaction

With the increasing interest in virtual environments (VEs) over recent years, and along with their rapid development, has come an understanding of the benefits of using such platforms for the study of social interaction. There are several such environments, for example immersive virtual environments (IVE) used in, for example, the work of Bailenson and colleagues [e.g. 1, 2]. Such environments allow the user a large amount of sensory stimuli, some of which is unavailable in non-immersive environments. One of the disadvantages of using such a platform for social presence / mutual gaze research is that they are expensive to use, are not widely available, and require specialist knowledge to build experiments in them. As a result, we have decided that,

despite the lower amount of available sensory information, we would use a more widely-available, and easier to use non-immersive virtual environment.

Second Life (SL) is a 3D virtual environment in which users are able to interact with other users and agents via an avatar (see <http://secondlife.com/>). It is currently used for all sorts of social interaction, from, for example, business to teaching. The default avatar behaviours are such that it approximates well to a face-to-face interaction in terms of the social cues afforded a user during interaction. The interface is relatively easy to use, and scripting facilities allow the import of a given task or paradigm, such as a problem to be jointly solved by two people, mirroring a real-world interaction in a more controllable environment. This paradigm can then be easily adapted to different domains. An on-line (as opposed to post-test) evaluation can be made of how individuals respond to a task by capturing the screen during the interaction, superimposing gaze behaviour, and analysing it in conjunction with other dependent variables, such as task performance. It is possible to access SL on the three main computer platforms. Despite the availability of other virtual environments, for the reasons already stated it was decided that Second Life best suited our purposes for studying social interaction within a highly controllable environment, and it was therefore the platform used for running our experiments.

It may be thought that conclusions resulting from humans interacting with either avatars or agents within a virtual environment would have only a loose relationship with previous findings on human-human behaviour. The user is well aware, after all, that they are not interacting directly with a person, therefore how can we conclude that any patterns of behaviour that are discovered would be the same as in a face-to-face, real-world interaction? Firstly, the default (and manipulated) avatar eye and body movements are very human-like. This means that during interaction with an avatar or agent users would be more likely to respond in a similar way to that of a face-to-face interaction than if the behaviour was non-realistic. Furthermore, there is evidence to suggest that certain non-verbal behaviours persist within a virtual environment. Yee and colleagues investigated the persistence of nonverbal social norms in online environments [21]. This was another variation of Argyle's Equilibrium Theory paradigm, in that they were observing eye contact and interpersonal distance between avatars in SL. There is also some evidence to suggest that avatars in Second Life are afforded similar social presence ratings as humans in a face-to-face interaction [22]. As such, it seems entirely reasonable to study the social manner in which humans

behave within a mediated virtual environment, such as users' eye movements, and allow for tentative generalisation into real-world interactions. We will now, therefore, look at users' eye movements during social interaction via virtual environments, including Second Life.

## 5. Eye movements in virtual environments

Much of the previous research into eye movements in Second Life has been dedicated to using eyes to control a user's avatar, a method especially valuable for individuals with disabilities that inhibit them from using a standard mouse and keyboard (e.g. [23]). Few studies have investigated the eye movements of users during interaction with Second Life. None have looked at the relationship between eye movements and social presence in Second Life.

Wismath and colleagues investigated users' eye movements during a ride on a virtual roller coaster simulation [24]. They manipulated the amount of presence that participants experienced by either providing an auditory channel (high presence) or not (low presence). They aimed to establish if there was a relationship between the patterns of eye movements and the level of spatial presence that the users experienced during the virtual ride. They discovered that high presence was related to a higher number of fixations, shorter fixation durations, smaller saccade amplitudes, and decreased saccade velocity than low presence. This paper outlines how behavioural and self-report measures could potentially be used in conjunction to measure presence. One of the issues here is that, although we have information about the patterns of eye movements, there is no report of what exactly within the environment is actually being fixated from moment to moment. It is unclear which objects are being attended to and, therefore, what these eye movements actually mean in terms of responses to specific stimuli. These measures of presence have been carried out in the spatial domain. If one were to attempt to adapt the paradigm to a social situation, how could eye movements potentially enhance an understanding of variations in social presence? In such a situation, it would be vital to know what was being attended to at any one time. In order to establish the social relevance of an object being looked at one would need to know if it was a human face – an object with high levels of social relevance – or, for example, a chair – an object with little social relevance.

## 6. Previous experiments – towards an on-line measure of social presence

In an initial study, we aimed to develop an experimental paradigm that would allow the investigation of users' eye movements during engagement with a programmed avatar (i.e. an agent) at the Virtual University of Edinburgh in Second Life (see <http://vue.ed.ac.uk/>) [25]. Some preliminary data concerning eye movements during task-focused interaction was also sought. The development of such a paradigm was anticipated to enable further investigation into how visual information presented by an agent would be used by the participants. Additionally, the paradigm would enable further investigation into how individuals utilise social vs. non-social information within a virtual environment. The agent assisted the user in the completion of several tasks, and the amount of looking at the agent, as well as task performance was recorded. An SR-Research EyeLink II head-mounted tracking system was used during the study to record eye movements of the participant during interaction with the agent. Camtasia Studio (TechSmith Ltd) recorded what the participant could see on the screen throughout the procedure, and a combination of both outputs enabled analysis of where the user was looking during the procedure. During the task, the agent either held visual information critical to completion of the task (i.e. non-redundant visual information) or he held redundant visual information. In a baseline condition the agent was invisible.

In all 3 conditions, the agent gave verbal instructions, but in the non-redundant condition these were not complete instructions; the user had to look where the agent was pointing in order to complete the task

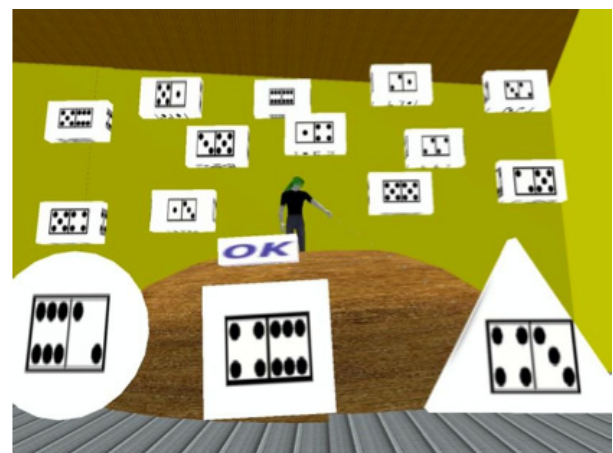
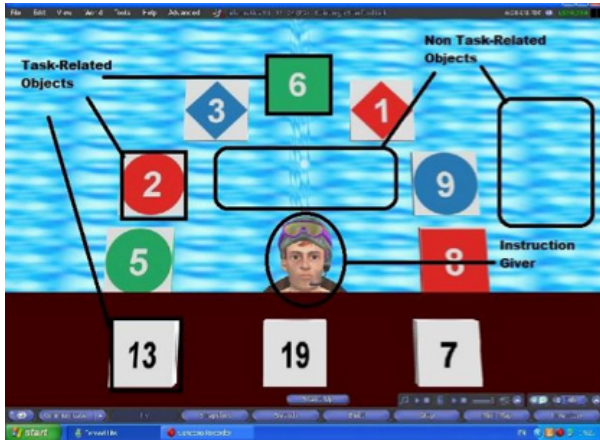


Figure 1: Participant's view of the agent in one of the visible conditions.



**Figure 2: Instruction Follower's View and Regions of Interest (black outlines; not visible in experiment)**

successfully. In figure 1, for example, he was instructing the user to find a tile on the wall that had the same number of dots as “...the one on the triangle” (redundant pointing) or as “...this one” (non-redundant pointing).

It was found, rather counter-intuitively – given the previous evidence on preferential attention attracted by faces [12-14] – that there was very little looking at the agent during the interaction. This could have been due to the complexity of the task, the task-related stimuli attracting more attention than the agent. This small amount of looking, however, could be increased by ensuring that the agent held task-critical visual information (i.e. in the non-redundant condition). It was also discovered that more looking at the agent in the redundant condition was detrimental to task performance. More importantly, the paradigm enabled the investigation of users' eye movements during Second Life mediated interactions. Although a previous study had looked at eye movements within Second Life, they observed the avatars, rather than the people controlling them [21]. This may not give an accurate indication as to the eye movements of the users driving the avatar; it would only indicate that their avatars were making eye contact.

As previously stated, some research has assumed that staring by one conversational partner at another maximises the amount of mutual gaze between the pair (dyad). If this is, in fact, not only behaviourally and socially unrealistic, but also unnerving for the person being stared at, how does the recipient of this gaze respond? In a second study, Dalziel-Job and colleagues utilised their previous paradigm to investigate mutual gaze during task-focused interactions in Second Life [26]. They aimed to establish if constant staring by one conversational partner at another does, indeed, maximise the amount of mutual gaze between the pair, and if not,

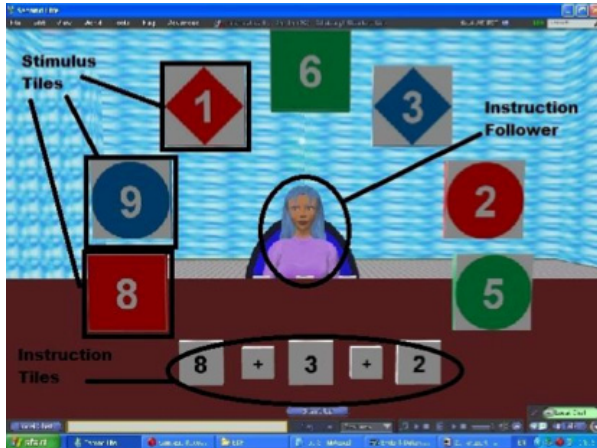
what effect does this staring have, on the other's looking behaviour and task performance. To do this, 2 participants communicated via Second Life to complete simple arithmetic tasks. Their avatars were seated either side of a glass screen on which were displayed numbers within coloured shapes. One participant acted as instruction giver (IG) and the other as instruction follower (IF) (see Figs. 2 and 3). Participants were fully aware that they were interacting with another human being.

The IG conveyed a short calculation to the IF without using numbers, but instead by describing the shape and colour of each number as it appeared on the glass screen. In one condition, the IG's avatar stared continuously at the IF – the staring condition, and in the other the IG's avatar looked at each number as he was describing them, and looked at the IF at all other times – the not-staring condition. It was discovered that, rather than maximising the amount of mutual gaze between the dyad, constant staring by one conversational partner at the other showed evidence of actually decreasing the amount of mutual gaze. It was further found that mutual gaze was positively correlated with task performance scores, but only in the not-staring condition. When not engaged in mutual gaze, the IF looked more at task-related objects in the not-staring condition than in the staring condition. It is unknown, however, what effect, if any, eye movements, and in particular the amount of mutual gaze between a dyad has on one individual's sense of another's social presence.

## 7. Proposed investigation of mutual gaze and social presence

With our next study we will use the existing paradigm to examine the relationship between mutual gaze, social presence perceptions and task performance measures. It also aims to investigate further various aspects of the previous study. It seems entirely reasonable to assume that there are social factors at work in our eye movements in Second Life study [26]. These factors may be discouraging an individual from returning the stare of their conversational partner, to avoid being, as Kendon suggests, “vulnerable to him” [15]. It could be argued, however, that the IF looked more at the IG during the not-staring condition because of the possible availability of visual information to assist in the completion of the task – i.e. the IG looking at the stimulus whilst describing it. Although this visual information was strictly redundant, this possible explanation needed to be tested. An adapted paradigm includes an additional baseline condition where the IG still looks at the tiles redundantly, but does not look





**Figure 3: Instruction Giver's View and Regions of Interest (black outlines; not visible in experiment)**

at the IF during the procedure at all. This would allow for distinction between attention attracted for task-related reasons (because the IG is looking at the tiles) and that attracted for social reasons (because the IF wishes to engage in eye contact).

The future study will also systematically vary the amount of looking by the instruction giver at the instruction follower. Given the social and task-related benefits of mutual gaze, it is of interest to discover what the optimum amount of looking by one person at another will maximise the amount of eye contact between the dyad. As previously discussed, it has already been established that this value is not 100% [26]. In this study, the IG will take the form of a programmed avatar – an agent – rather than a human. This will allow tight control over the amount of IG looking at IF, which could be inconsistent across trials if a human were to be controlling the IG.

The independent variable agency will be included in the proposed study, meaning that users will either be told they are interacting with an avatar (human controlled) or an agent (computer controlled). It is anticipated that different social perceptions of the IG will be elicited in the avatar and agent conditions. These differences will be verified using a social presence questionnaire administered within the SL environment [8]. Finally, the IF's eye movements will be recorded in order to identify the relationship between eye movements, agency and perceived social presence of the IG. Task performance will also be recorded.

The proposed study, therefore, will incorporate subjective report and on-line, behavioural measures, and aims to develop an on-line measure of social presence, using eye movements. This has the potential to

supplement existing questionnaire-based measures to produce a fuller understanding of social presence perceptions during task-based interactions with a virtual being. It is further anticipated that the results will give insight into what is driving mutual gaze, and how much an individual engages in during a task-focused interaction.

## Conclusions

The majority of social presence research currently relies heavily on subjective post-test questionnaires, which may not tell the whole story. An ideal complement to such tools would be an objective on-line measure. Mutual gaze plays an important role in social interaction, and is known to be related to an individual's social perceptions of their interlocutor. A paradigm has been created within Second Life to investigate what relationship, if any, there is between mutual gaze and social presence. The proposed study, therefore aims to establish the nature of this relationship, and develop a fuller understanding of the nature of Social Presence, and how it relates to task performance and mutual gaze.

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