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Deconstructing Mere Presence and Audience Effect During Videoconferencing: Video versus Screen-Sharing Mediated Performance Changes

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Data Availability

The anonymised research data is publicly available on the OSF page: https://osf.io/tw46x/files/fb6kp

The avatar companion metadata file is uploaded to the OSF page: https://osf.io/tw46x/files.

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Abstract

The study aims to understand how the impact of social presence on task performance (social facilitation effect), usually measured in face-to-face settings, can be generalised towards remote videoconferencing. The social facilitation effect is expressed in the improvement of task performance on easy tasks, and detriment on difficult tasks, during a social situation versus when performing alone. We tested which videoconferencing channels are responsible for this performance change. The interaction occurred within an experimentally controlled naturalistic videoconferencing setting. The participants performed visual-reasoning tasks as quickly and accurately as possible under several conditions: when screen-sharing their task performance, having their video on, seeing the video of the researchers' interactive avatar, and with all these channels on or all off. Based on two social facilitation effect phenomena, we predicted that participants' performance might change when it is watched (audience effect) by the researcher through screen-sharing and when participants or the researcher co-share their videos during videoconferencing (mere presence effect). We found that having participant video visible to the companion improved participants' performance accuracy on difficult tasks, whilst task screen-sharing improved speed on correct easy tasks, with no significant effect from the researchers' visual presence. We entertain the notion of soft-presence and propose ways forward.

Keywords

Videoconferencing, Avatar, Mere Presence Effect, Audience Effect, Social Facilitation

Deconstructing Mere Presence and Audience Effect During Videoconferencing: Video versus Screen-Sharing Mediated Performance Change

With an emerging trend in remote work and education, the social world is becoming more virtually and digitally interconnected. Nonetheless, there is still little known about how daily communication technology choices impact the brain and behaviour and most importantly, why. The psychological and cognitive sciences offer a rich insight into social cognition and its effects on the brain, behaviour and cognitive performance, with theoretical and experimental findings spanning over a century. However, to apply these theories in the technological communication domain, we need to establish whether classic social effects could be generalised in the world of virtual and digital communications. By understanding where these classic effects are generalisable and when they break down, we can learn more about these effects in more detail, develop new theoretical frameworks relevant to remote communication technologies and learn how to utilise these technologies with human cognition in mind. The current study is one step closer towards this goal.

Social Facilitation Effect

In this study, we explore whether a classic social facilitation effect (Bond & Titus, 1983; Mennecke et al., 2010; Zajonc, 1965) can be elicited through a remote videoconferencing interaction. The effect has been studied within an in-person interaction context for over a century and has held its effectiveness with reasonable effect sizes over the years (Bond & Titus, 1983). The benefit of exploring this effect is that it offers a clear prediction trajectory on how social context, such as being observed (**Audience Effect: AE**, Guerin, 1983; Hamilton & Lind, 2016) or being co-present with others in the same environment (**Mere Presence Effect: MPE**, Guerin, 1986), impacts task performance alongside others. In this case, the ability to perform a visual executive reasoning task called the relational reasoning paradigm (RRP, susceptible to the effect: Dumontheil et al., 2016). The canonical social facilitation effect is expressed in improvement on easy and well-learned tasks, and detriment on difficult and unfamiliar tasks, alongside others, versus when performing alone (Guerin, 1983; Guerin & Innes, 1984).

Although the effect trajectory is fairly established, there are still debates around whether the two mechanisms (MPE and AE), by which social facilitation occurs, are truly independent. With suggestions that mechanisms could be a continuum of the same cognitive-affective process at a lower (MPE) and higher (AE) level of social mentalising in humans (Hamilton & Lind, 2016). Due to MPE and AE often co-occurring in the natural in-person social interaction setting, ecologically valid disentanglement of these two social facilitation mechanisms in that setting is a challenge.

We suggest that these mechanisms could be systematically manipulated through videoconferencing channels, separating co-presence (MPE) from observance (AE) in a naturalistic way, easing further testing of the mechanisms. This, of course, if MPE and AE can be translated into a videoconferencing setting, which we aim to test.

Mechanisms of Social Facilitation: MPE and AE

Although both MPE and AE result in social facilitation, it is assumed that the social processing involved in giving rise to the effect differs in each mechanism.

For MPE, the social facilitation arises through heightened social vigilance, uncertainty, and preparedness that people experience when they believe there is someone else physically present in the same environment (co-presence). This MPE-driven response to social others' co-presence is believed to be a more primitive response to uncertainty of actions in the same space – something humans share with other animals (Guerin & Innes, 1982; Rajecki, 2010; Rajecki et al., 1977). Supporting this notion, MPE-related processes involve divided attention between the task and the co-present others, a vigilance response to resolve uncertainty about others' intentions (Sanders, 1981; Sanders et al., 1978). And a heightened state of self-monitoring and embodied composure, i.e., adjusting one's own body to a more controlled position in preparedness to socially engage, such as posture adjustments and more restrictive embodied behaviours (Guerin, 1983, 1986). It is assumed that MPE does not relate to performance evaluation by others, because MPE-based social facilitation also occurs when co-present confederates are blindfolded or occupied by peripheral tasks whilst sharing the space with participants (Rajecki et al., 1977; Schmitt et al., 1986).

In contrast to MPE, the AE-related cognitive processes are linked to anticipating evaluation or judgment from others. When participants believe they are observed, AE manifests in compensatory public reputation management strategies and behaviours to demonstrate more prosocial actions or performance abilities (Bond, 1982; Bond & Titus, 1983; Chevallier et al., 2014; Cottrell et al., 1968; Grant & Dajee, 2003; Hamilton & Lind, 2016). Unlike lower-level social processes attributed to MPE (attention, uncertainty, state of preparedness), AE-related mentalising is believed to be higher-order and human-specific, influenced not just by direct response to the physical environment, such as others' co-presence in the same space, but by subjective beliefs of own competency and others' expectations and evaluation of it. Indeed, AE was reported when participants believed they were being watched through a camera whilst performing cognitive tasks in the lab settings, without observers physically present in the same room (Dumontheil et al., 2010, 2016).

The main discrepancy of MPE and AE seems to lie in the former relating to action uncertainty resolution and the latter on self-evaluation and others' judgment of own abilities and behaviours.

Videoconferencing Disentangling of MPE

The in-person MPE is driven by social co-presence in the same room, i.e., physically sharing the same space with others. There are, however, still debates over what constitutes social co-presence in digital realms (audio, haptics, synchronised texting, etc.; Lee, 2004). In this report, we have chosen visual co-presence for videoconferencing MPE because we believe that the video channel is more likely to elicit the behaviours reported for MPE during in-person interaction. It is possible that physical co-presence may be essential for MPE, because the vigilance response is heightened due to the expectation of the confederate physically engaging the participant. In this case, the effect might not arise during videoconferencing as the confederate cannot physically touch the participant through this medium.

However, if MPE is driven by vigilance and attention mechanisms due to the social uncertainty and preparedness processes related to self and others' actions whilst sharing the same space, irrespective of physical encounter, the MPE could be achieved remotely. Videoconferencing software offers a virtual “space” that enables video channels to expose both participants and companions to each other within the same interface. Without a concrete goal of performance monitoring (related to AE), both the participant and companion are arguably just visually co-present, without any additional intent. If this level of **visual co-presence** is sufficient for MPE, turning cameras on will result in a social facilitation effect.

Both companion (confederates) visual presence (**CVP**) and participants' self-visual presence (**SVP**) video channels could be important to establish a sense of co-presence necessary for videoconferencing MPE-based social facilitation. However, it is unclear whether both channels are required for the effect to take place, or whether one channel could be more essential than the other.

Intuitively, the companion's visual presence (CVP) is a necessity for co-presence MPE-based social facilitation to take place. The MPE-related vigilance and divided attention mechanisms during co-presence of another person could be triggered by social attention needs to monitor other people in the same environment, in this case, a shared videoconferencing space (Guerin, 1983; Guerin & Innes, 1982, 1984; Rajecki, 2010; Sanders, 1981). Findings suggest that any human-like visual biological motion attracts people’s attention and excites the social and attention networks of the brain (Puce & Perrett, 2003; Williams et al., 2019). If this visual level of CVP is sufficient to attract participants' attention and elicit a social vigilance response in isolation, then we expect the companion visual presence (CVP) to contribute to videoconferencing MPE, independent of the participant’ SVP.

Arguably, there cannot be co-presence without self-presence. During in-person co-presence, the visual self-presence of the participant in the same room alongside the confederate is often given. During videoconferencing, this is not the case, as the camera can be switched off. The SVP could be essential for MPE to occur, because through self-exposure, the participant is no longer an invisible onlooker, instead someone whose visual co-presence, actions and reactions are known to another person. Acknowledging the self as a participatory agent in a social situation sets a person into a state of second-person cognition (Schilbach et al., 2013). A state that has been shown to activate participants' brains differently than when they are passively looking at social situations unfold, employing additional brain regions relating to social planning and self-referential cognition (Cañigueral et al., 2022; Redcay & Schilbach, 2019; Schilbach et al., 2013).

When no clear instructions are provided, being visible through a camera to others seems to evoke heightened levels of embodied self-awareness, with participants checking their image and adjusting their posture when the camera is on (Miller et al., 2017). These behavioural changes in posture and demeanour are similar to the ones expressed during in-person MPE when participants are just co-present but not monitored or evaluated by the confederate (Guerin, 1983). There is also neurofunctional activation in participants' social and self-awareness networks, which occurs when participants believe the camera is on, irrespective of the task or other kind of evaluation (Izuma et al., 2010; Somerville et al., 2013). These findings suggest that being visible through a camera is a significant trigger for vigilant self-monitoring in a social context, as expected from social preparedness behaviours in MPE. Interestingly, although intuitively it seems that seeing oneself on camera is distracting (reducing performance), the tests show that performance improves (faster) when the seeing-self option is on vs off during videoconferencing, in what the authors called heightened objective self-awareness (Hassell & Cotton, 2017). In a way, seeing oneself through videoconferencing during a video call with others could be a reminder of being co-present in a digital context, compensating for the lack of physical co-presence. Therefore, we will test the effects of SVP on MPE-based social facilitation in isolation as a minimal requirement for the state co-presence – self-presence. To ensure this highest level of self-presence, the SVP condition will have the habitual self-visibility option "on" when sharing video with a companion

Considering that both CVP and SVP factors can be systematically controlled during videoconferencing gives a unique opportunity to test the effects out in isolation and as an accumulative interaction. The first aim of this study is to test whether we can elicit social facilitation through these channels alone (SVP or CVP) and then explore if CVP adds any additional effect to SVP in a separate analysis (SVP + CVP).

Disentangling Videoconferencing AE

In contrast to MPE, performance visibility is essential for AE. Luckily, performance visibility is a feature that can be easily changed during videoconferencing, irrespective of participants' SVP or CVP video visibility, using a currently well-known performance screen-sharing (PSS) function in videoconferencing software. Although testing videoconferencing AE seems to be more straightforward (switching PSS channel on or off), the software enables testing additional research questions relating to the social AE as a context mechanism on itself.

During in-person AE testing, the participants are often observed alongside their performance (Guerin,1983), even in newer experiments using an in-lab camera observation (Dumontheil et al., 2016; Wolf et al., 2015). Because of that, it is difficult to experimentally separate the participants' visibility (SVP) from the performance (PSS). Arguably, without this separation, it is challenging to establish which aspect of participants' performance under observation influences the AE – whether it is the visibility of task performance alone or being seen alongside performance. Videoconferencing enables a systematic separation of participants' performance (PSS) visibility alone and being visible alongside their performance (SVP), elucidating the requirement for AE-based social facilitation.

Research into occupational performance monitoring software demonstrates that participants' performance ability changes the moment they are told that their performance is monitored by another person, irrespective of being seen in person, or seeing the observer and knowing who they are (Aiello

& Kolb, 1995). If AE-based social facilitation is indeed just driven by performance monitoring, the effect will emerge through task observations alone (PSS), irrespective of SVP or CVP. We will test this effect (PSS) in isolation.

However, demonstrating calm composure during task evaluation could be an additional factor to showcase competence. If so, the reputation management strategies associated with AE could extend beyond just the performance ability and towards a more combined portrayal of competence through the additive effect of performance ability and public expression of being in control when performing. A public display of such interaction is often expected from competent performance professionals (Manning, 2020; Sundaram & Webster, 2000) and has been shown to affect emotional and cognitive resources (Richards & Gross, 1999). Therefore, it is possible that being visible (SVP) whilst showcasing task performance ability (PSS) could be essential, or at least an additional, impactful contribution to AE-related social facilitation. We will explore this effect by contrasting performance outcomes when just screen-sharing versus when screen-sharing and being video-present (PSS + SVP).

Furthermore, although previously AE has been reported through a camera without a visible observer (Dumontheil et al., 2016; Wolf et al., 2015), seeing audiences during performance monitoring could potentially contribute significantly to the AE-driven effect. A visible audience's attitude, reaction and predispositions towards the performer's abilities as they perform can guide the performer. For example, when presenting, people often gaze at their audience for such feedback to modulate their performance and state (Kawase, 2009). Therefore, although AE could be driven by the belief of task observation alone, being able to see the observer in anticipation of evaluation feedback cues could add to the effect. To explore this, we will contrast task outcomes when performance screen-sharing (PSS) alone versus when screen-sharing is used alongside a visible companion (PSS + CVP).

Companion Type

This study is interested in companion interactive synchronous visual presence and monitoring rather than the impact of their visual attributes. Therefore, instead of a realistic video feed of the researcher, we used an interactive avatar that live-tracked researchers' facial expressions, body, eyes and mouth movements throughout the videoconferencing session. The researcher greeted the participant in the avatar form (talking through an audio channel) and guided them through the procedure and testing session as an avatar, ensuring participants are fully aware that the character has a person behind it.

The avatar and digital face-filters are becoming more normalised in many remote interaction contexts, from social media to education, with implications for healthcare use (Ozono et al., 2025). It is timely to test whether a visual representation of an authoritative (researcher) companion, without their original features, suffices as a significant presence during the interaction. especially when evaluating performance (AE).

A person's avatar represents their interactive visual presence, without giving too much detail about their real features, reducing potential bias related to the visual attributes behind the mask (age, visual aesthetics and appearance, ethnic background, etc.; Lee et al., 2014; Lee, 2009). This approach ensures that participants engage with the idea of the visually present researcher and their actions, not their internalised biases towards the researcher's attributes. This visual avatar mask could benefit the social facilitation effect, as occlusion tends to increase uncertainty (important for MPE, Joinson, 2001) and reduce noise of interpersonal bias from the evaluative condition (relevant for AE, (Ozono et al., 2025).

Limitations

Of course, using this companion type could also reduce the social facilitation effect due to a lack of realism. The lack of avatar realism (such as a real-person video) and the unusual appearance of an avatar could be distracting (George et al., 2022; Lyyra et al., 2018; Yee et al., 2013) or be ignored as due to insufficient social cues (Strojny et al., 2020). Previously, we found that avatar companion and realistic human videoconferencing influenced participants' task performance differently during AE, the former facilitating accuracy on difficult tasks and the latter just speeding up easy tasks (Sutskova et al., 2022). This study will investigate the impact of the avatar further by switching its visibility on/ off. Future studies should investigate realistic-human contrast.

The participants' self-video SVP could also be distracting to themselves. During in-person MPE and AE, participants usually have no mirror to observe themselves through and seeing a video of oneself during videoconferencing draws participants' attention (George et al., 2022). This study tests the assumption that SVP elicits a heightened state of self-awareness whilst participants are seen and see themselves on camera (typical during videoconferencing). Further studies should consider separating participants' visibility of self-versus to companions to test this effect further.

Overall, if CVP and SVP result in negative performance effects without social facilitation, it is fair to assume these factors are introducing a visual distraction rather than MPE and AE-driven social facilitation effects.

Hypotheses and Planned Comparisons

H1: Mere Presence Effect (MPE). The first set of analyses tests whether videoconferencing channels contribute to performance impact, irrespective of the participant's performance being monitored (the PSS channel). We analyse performance changes during the switching of the channels related to SVP and CVP, irrespective of one another, or as an additive effect of turning CVP from off to on when SVP is on. ***H1.a*** predicts that if companion visual presence (CVP: on) versus absence (CVP: off) will result in social facilitation performance outcomes, the result is related to MPE. The ***H1.b*** predicts that if participants' self-presence on video (SVP: on) versus absence (SVP: off) will result in performance outcomes, the result is related to MPE. ***H1.c*** (explorative) predicts that if the MPE in the videoconference-based setting is additive, based on the visual co-presence of both parties, then there should be SVP x CVP interaction, with performance facilitation when tuning CVP from off to on, when SVP is on, versus performance when SVP is on and CVP is off.

H2: Audience Effect (AE). The second set of analyses tests the AE related to performance changes. The ***H2.a*** predicts that if performance screen-sharing (PSS: on) versus not (PSS: off) will result in social facilitation of task performance, the AE can be elicited by PSS alone, irrespective of SVP and PSS. ***H2.b*** (explorative) predicts that if AE in the videoconference-based setting is additive, based on being visible when performance is monitored, then there should be PSS x SVP interaction, with performance facilitation emerging when tuning participants' visibility on (SVP: on) when performance screen sharing is on (PSS: on). ***H2.c***. (explorative) predicts that if AE is driven by being able to see the task observer when sharing performance, there should be a social facilitation effect when turning companion visual presence on (CVP: on) when screen-sharing (PSS) is on.

Difficulty. The difficulty of task levels is included in the design to explore the canonical social facilitation effect-related interaction between social impact and task difficulty in in-person studies, with expected better performance on easy tasks and worse on difficult tasks during social versus alone. Our primary analyses in this study will look into how SVP, CVP and PSS channels are affecting performance within each difficulty level (**Figure 1**) within the MPE and AE framework. To do so, we conduct planned follow-up paired comparisons of performance changes between on and off states of each channel in easy and difficult conditions separately. Considering our prior findings also found significant facilitative main effects irrespective of difficulty (Sutskova, Senju, & Smith, 2022), we will investigate the main effects alongside the difficulty interaction.

Figure 1

Videoconferencing Channels Are Represented As Independent Variables At Each Level Of Difficulty

SVP: Self Visual Presence	CVP: Companion Visual Presence	PSS: Performance Screen Sharing	Difficulty
Off On	Off On	Off On	Easy Difficult

Methods

Participants

Out of 30 participants recruited, $N = 27$ participants (20 female, 7 male), age range 19-45 ($M = 27.2$, $SD = 7.7$), working or studying in London, United Kingdom, were entered into the final within-subjects analysis. Our participants were recruited within a neurotypical population from various ethnic backgrounds, and self-reported as not having a clinical diagnosis of autism spectrum disorder (ASD), attention deficit hyperactivity disorder (ADHD), or anxiety disorders.

The target analysis sample size, $N = 24$, was estimated using G*Power ANOVA repeated measures, within factors (groups 1, measurements 4), at $1\text{-}\beta = .8$, $\alpha = .05$, Cohen $f = .44$ ($\eta_p^2 = .162$), The sample estimation was motivated by a significant 2 (Audience) x 2 (Task) within-subject AE-based interaction ($p = 0.020$; $\eta_p^2 =.162$) using the RRP cognitive task performed in this study (Dumontheil et al., 2016). An additional six participants (25 per cent of the sample estimation) were recruited to account for an estimated drop-off rate based on our earlier similar video-based paradigm (Sutskova, Senju, & Smith, 2022). Out of N=30, 3 participants did not believe that the researcher was behind the avatar companion, as per the prompt at the end of the study and were removed from the analysis. The $\boldsymbol{N = 27}$ participants were sufficient to detect explorative three-way ANOVA interaction (groups 1, measurements 6), with effect size of Cohen $f = 0.203$ ($\eta_p^2 = 0.32$ as per G*Power SPSS equivalent calculation), at $1\text{-}\beta = .8$, $\alpha = .05$.

The participants were enlisted through an online participant recruiting system (SONA), advertised by targeting individuals with an interest in technology. All participants were required to have access to a personal computer with a working keyboard, a video conference-ready camera and audio setup, and a stable internet connection. The study was approved by Birkbeck, University of London, Psychology Department Ethics Committee, approval number: 192084.

Design

We have systematically manipulated four within-subjects factors thought a videoconferencing user interface (see ***Interaction Layout: Figure 2***), the Self-Visual Presence of the participants' video to the virtual companion (SVP: Off, On), the Shared Performance Presence of the participant task screen to the virtual companion (PSS: Off, On), Companions Visual Presence in the participants' companions (avatar) video window (CVP: Off, On), and the Difficulty of the cognitive task performed by the participants (Difficulty: Easy, Difficult). Similarly, to Sutskova, Senju, & Smith, 2022, we have used the Relational Reasoning Paradigm (RRP), **Figure 3** below**,** a visual logic task, susceptible to in-person AE impact (Dumontheil et al., 2016). Similarly to our previous study on virtual companion impact (Sutskova, Senju, & Smith, 2022), the participants' cognitive performance on the RRP task was measured both in per cent accuracy and in reaction times (RT) per accurate responses only.

Live Avatar Companion

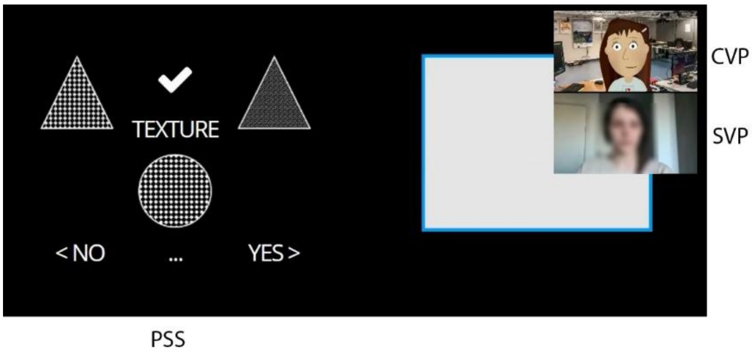
The avatar companion was derived from Adobe library free presents ("Cassandra") and visually altered by the researcher in Adobe Photoshop software to be more visually appropriate for the research testing purpose. The altered avatar pupped can be found on our OSF page: https://osf.io/tw46x/files. The avatar was then digitally live-puppeteered using Adobe Character Animator software, which tracked the researcher's facial expressions, body, mouth and eye movement. The avatar live feed was then broadcast into Zoom.sc messenger software virtual camera of the researcher through open source, Open Broadcast Software (OBS).

Videoconferencing Interaction Layout

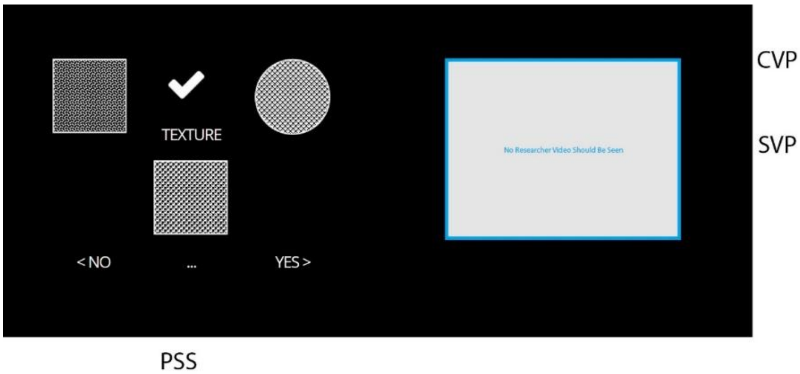
The video conference-based interaction between the participant and the researcher was established using the currently widely used online video chat software, Zoom Messenger (Zoom.us). Both parties (researcher and participant) were using software features to share their video and audio throughout remote communication. The participants, who participated remotely from their homes, were using the Zoom screen-share option to project their task display to the researcher when asked to do so. Depending on the instruction, the participants performed under all possible combinations of channels turned on or off, including none of the channels and all channels on or off. **Figure 2** illustrates the participant's view of the videoconferencing interaction when all channels were on (a) and off (b).

Figure 2

Participants' View of the Task and Video Channels When All Visibility Channels Are On (a) versus Off (b).



a. Visibility of All Channels is Turned On: *the participant <u>can see</u> the companion (CVP), and themselves (SVP*), on the right side of the screen. The participant can see their task performance (PSS) on the left, and because screen-sharing (PSS: on) is on, they also share their performance with the researcher. Participants are made aware that their video and task performance are visible to the researcher. *The participant's face is blurred for publication purposes.*



b. Visibility of All Channels is Turned Off: *participants <u>cannot see</u> the companion (CVP: off) or themselves (SVP: off) on the right side of the screen. Participants can see their task performance on the left but are not screen-sharing the performance (PSS: off) with the researcher (companion). Participants are aware that their video and task performance are not visible to the researcher.*

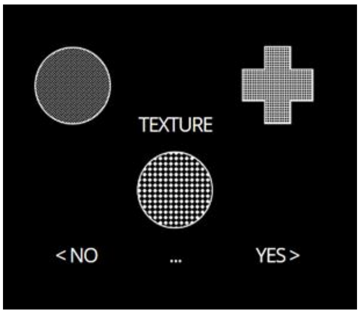
Cognitive Task

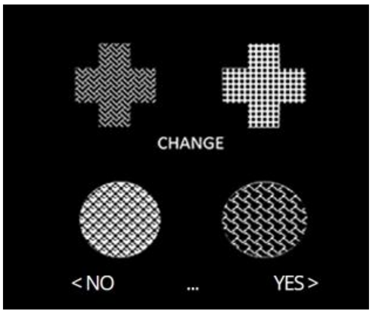
The cognitive task was developed within an online experimental task engine (Gorilla.sc), enabling participants to access the experiment from their homes. The cognitive task used was identical to the task used in the original experiment (Sutskova, Senju, Smith, 2022), which was a modified version of the visual logic task, Relational Reasoning Paradigm (RRP) used for AE by Dumontheil et al., (2016). The task consisted of two difficulty levels of timed visual pattern and shape-matching trials.

The easy task level consisted of three images, two at the top and one at the bottom. The participants were asked to either match the shape or texture (never both) of the top row images to the image on the bottom row (**Figure 3.a.).** If the top and bottom rows matched (in shape or pattern), the participants clicked the right arrow for "yes", if not, the left arrow for "no". For the difficult task (**Figure 3. b**), the participants had to focus on the dimensions of changes occurring at the top and bottom rows of the task and decide whether the top and bottom row images change in the same way. The top row dimensions changed either in shape or pattern, and the bottom row also changed and pattern. If both changed in the same way, i.e., pattern, the participants answered "yes", if in different ways, then "no".

Figure 3

Relational Reasoning Paradigm Cognitive Task Examples of Easy (a) and Difficulty (b) Trial

a. Easy 

b. Difficult 

Note:

In the figure examples, the correct answer for the easy task **(a)** is "no", because the instruction is to match "TEXTURE", and neither of the textures in the top two images matches the texture in the bottom image. If the instruction was to match “SHAPE”, the answer would have been “yes”, because one of the top images is a circle, and so is the bottom image.

For the difficult task **(b)**, the correct answer is “yes”, because the participants are asked to match the dimension of how the top and bottom images “CHANGE”. In this example, the top two images change in texture but not shape (both plusses), and the bottom two images also change in texture, but not shape (both are circles). Therefore, the top and bottom rows “CHANGE” in the same way (same dimension, texture, but not shape).

Each social context (SVP, CVP, PSS none, or a combination of each) consisted of four easy and four difficult blocks presented in randomised order. Each block consisted of 5 easy or difficult trials, and each trial lasted a maximum of 3.5 seconds. The task window was always presented on the left side of the participants' screen, whilst the video windows were always hovered in the white box on the right side of the screen (**Figure 1**). There was a total of 320 trials lasting 3.5 seconds each. The maximum duration of a testing session per participant was around 30 minutes (20 minutes for trials + additional time for Zoom software channel switching to condition-specific on-screen instructions). If did not complete the trial in 3.5 seconds, the answer was counted as incorrect and was not counted towards correct responses or RT outcomes for correct responses only.

Social Impact Cover Story

All participants were told a cover story to ensure not to overanalyse the social nature of the experiment. Participants were made to believe that we were testing new software that gathers users' self-video or screen-share task data to predict their real-time performance outcomes. The participants were told that, due to our online testing software being a pilot, we wanted to make sure that it works well under different media processing loads. The participants were reassured that the researchers' avatar was supposed to induce a higher processing load for the program, unlike the live video of researcher, therefore, the avatar needed to be used throughout. The researcher (in avatar form) was believed to be accompanying the participants to manually note down their performance, as seen through the participant's screen share, to later “troubleshoot the software”.

Media Channels and Switching Instructions

Before the onset of each new social context block, the participants were given on-screen instructions referencing the media channel condition they should set up in the next set of trials (**Figure 4**). The instructions were presented with intuitive, illustrative icons that the participants were familiarised with in the practice sessions. For example, in **Figure 4,** in the top "Participants" row**,** the participants are requested to turn off screen-sharing (PSS: off), whilst keeping their video on (SVP: on). The bottom "R1" row is for the researcher, suggesting turning their video off (CVP: off). The cross-over icons meant that the media was supposed to be turned off. When PSS was off for participants, the R1 row also shows that no performance marking will occur from the researcher's perspective (cross-over icon with a pen in R1, **Figure 4**).

The instructions and the participant task were always presented on the left side of the screen, whilst the video windows (with SVP and CVP) were always hovering around the white box on the right. When the videoconferencing setup was complete as per instructions, the participants pressed the "next" button to continue with the trial blocks under the new experimental condition, ensuring participants were aware and in control of the changes and conditions.

Companions Visual Presence (CVP)

The CVP conditions involved switching the companion camera on or off, with instructions directed at the researcher (**Figure 4**, bottom row "R1") rather than the participant. As the researcher turned the camera on (CVP: On), the participants could see the researcher's interactive avatar in their companion's video window. The CVP: off condition restricted participants from seeing the researcher's interactive avatar.

The researcher was on the video call throughout the study. For the avatar visual present versus absent conditions, the CVP blocks were counterbalanced, the study started with the avatar present (CVP: on) for some participants or absent condition (CVP: off) for others for half the testing session, and the complementary condition followed (randomised). If the CVP was off at the testing onset, midway through the study, the participants were notified by the on-screen task instruction that they should now ask the researcher to turn on their video. No participants failed to follow this request as they anticipated these instructions (as practised during the practice session) and had an audio channel enabled for emergency communication.

Self-Visual Presence (SVP)

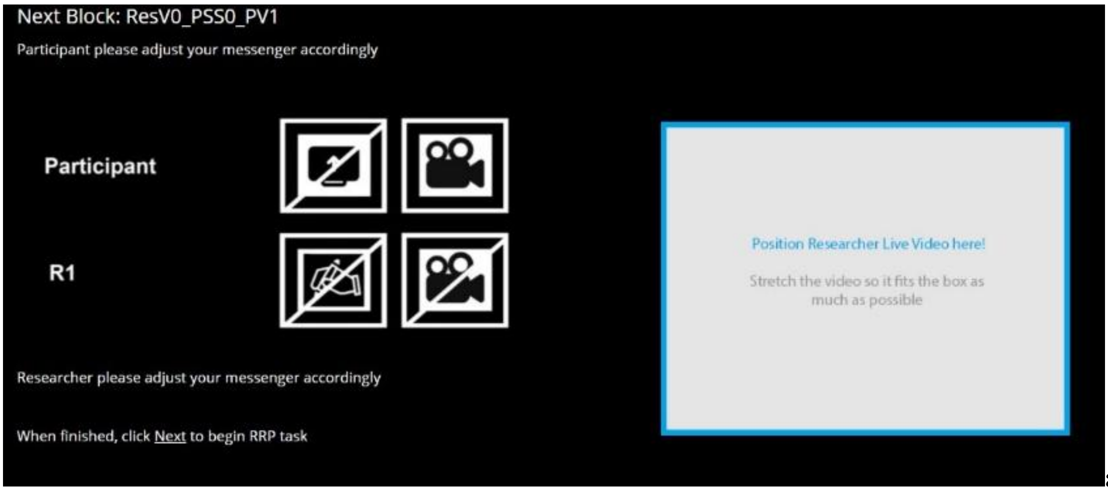
The SVP conditions required the participants to switch their self-camera either on or off, enabling the researcher to see participants' videos as they partake in the experiment (**Figure 4**, top row "Participant"). The switching of SVP occurred alongside the switching of other conditions. During the SVP: On condition, both the participant and the virtual companion could see the participant's video.

Performance Screen Sharing (PSS)

For the PSS conditions, the participants were required to turn their task screen share, either on or off, based on the onscreen instructions. Switching the SPP on, displayed participants' performance to the researcher. Screenshare switching occurred alongside switching of other conditions (SVP, CVP), during which the participants could have had an option to share their screen, whilst either being video present (SVP: On) or not (SVP: Off), and either seeing the researcher's interactive Avatar (CVP: On), or not (CVP off) respectively.

Figure 4

A Screenshot of Task Instructions for The Participant ("Participant") and the Researcher ("R1").



a

Procedure

Before participation, the participants were sent a password-protected Zoom messenger link, logged into the videoconference software, and greeted by the researcher in avatar form. The participants were told to only share their video and screen share after they were confident that their computer and home environment were appropriate for the study. They were then directed to the software setup instructions, during which the video windows were arranged to the right side of the screen, where they remained throughout the study, with the instruction and task screen always remaining on the left side of the screen and the emergency audio channel on. The participants were then directed to the practice session, where they practised the RRP tasks and media switching based on the icons presented on the screen (see **Figure 4**).

After successful completion of the practice session, with over 50% accuracy, the participants proceeded to the experimental trials, performing the RRP task, whilst switching between the social contexts as per instructions. Before completion of the experimental session, all participants were asked about their beliefs about the avatar's representation of the researcher, followed by a full debrief of the cover story and the actual purpose of the study. Participants were given the option to retract their data after debriefing if they did not feel comfortable with the cover story (none retracted). Participants who did not believe the researcher was behind the avatar were removed from the analysis.

The total dedicated study time was an hour, which, in addition to the 30-minute experimental testing session, included a general introduction to study and avatar interaction, Gorilla.sc and Zoom.sc messenger layout setup and practice, RRP task practice, Zoom onscreen instruction practice, and finally debrief and questions after experimental trials completion. The participants reported that the experimental session was interactive and engaging, and they did not feel fatigued during performance.

Results

Results for an omnibus four-way ANOVA of four factors: CVP x SVP x PSS x Difficulty. Due to a significant positive skew of the data, all analysis values reported are Greenhouse-Geisser corrected. The summary of the means and standard errors (SE) by each level of each factor of the current study is presented in the summary tables at the end of this section. ***Table 1*** for per cent (%) accuracy and ***Table 2*** for RT of accurate responses in milliseconds. All follow-up contrast analyses are Bonferroni corrected. As per the **Hypotheses and Analysis Plan**, the primary social impact effects are explored at each difficulty level and post-hoc analyses as the main effects of CVP, SVP, and PSS.

Difficulty

As expected, the difficult tasks were performed significantly slower, F (1, 26) = 158.8, $p <$ .001, $\eta_p^2 = .859$ (difficult M = 1922.87, SD = 333.02, easy M = 1390.97, SD = 277.41) and less accurate than easy tasks F (1, 26) = 37.11, $p < .001$, $\eta_p^2 = .59$ (difficult M = 76.40, SD = 14.3, easy M = 91.60, SD = 4.60).

H1: Mere Presence Effect (MPE)

For MPE, we analysed the individual contribution of effects of self-visual presence (SVP), companion visual presence (CVP) and the additive combination of both.

H1.a: Companions Visual Presence (CVP)

There was no significant impact of CVP on participants' performance. There was no main effect for CVP for accuracy F (1, 26) = 0.82, $p = .38$, $\eta_p^2 = .030$, nor for RT F (1, 26) = 0.01, $p = .92$, $\eta_p^2 < .001$.There was no CVP x Difficulty interaction for accuracy F (1, 26) = 0.78, $p = .78$ $\eta_p^2 =$ .003, nor RT F (1, 26) = 0.26, $p = .64$, $\eta_p^2 = .010$. The planned follow-up tests were non-significant.

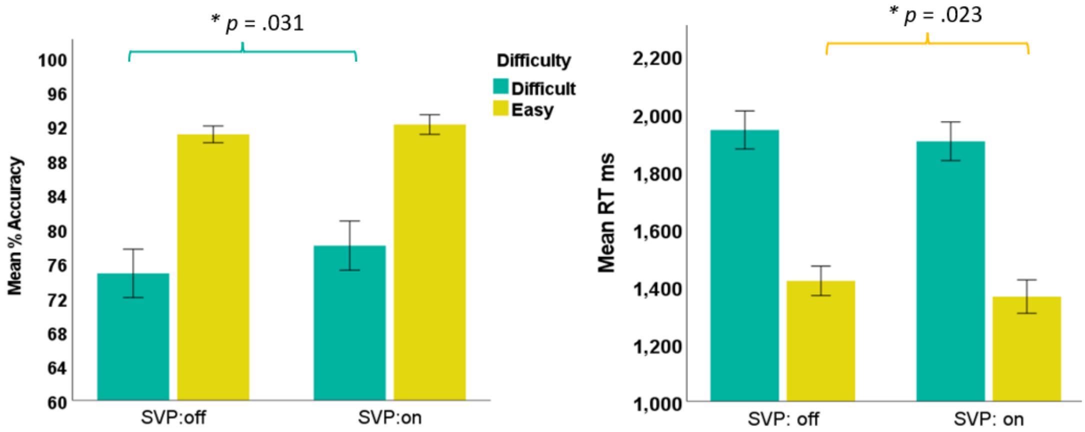
H1.b: Self-Visual Presence (SVP)

There were significant overall facilitation effects driven by SVP. There was a facilitative main effect of SVP on the participants' performance, significant in accuracy F 1, 26) = 4.77, $p = .038$, $\eta_p^2 = .155$, and marginal in RT F (1, 26) = 3.57, $p = .070$, $\eta_p^2 = .121$. The main effect of SVP demonstrated that, overall, when participants were visible to the companion (SVP on), they performed more accurately (SVP: on M = 85.10, SD = 9.09, SVP: off M = 82.90, SD = 8.57) and faster (SVP: on M = 1605.88, SD = 307.42, SVP: off M = 1647.19, SD = 281.88).

For planned analysis, there was no significant SVP x Difficulty interaction for accuracy F (1, 26) = 1.63, p = .214, η_p^2 = .059, nor RT F (1, 26) = .251, p = .621, η_p^2 = .010. However, as planned breaking down effects by the difficulty showed that turning the SVP on had significant facilitation effects specifically on a difficult task accuracy (SVP: off M = 74.80, SD = 14.55, versus SVP: on M = 78.03, SD = 15.06), p = .031, η_p^2 = .168 and easy task performance speed (SVP: on M = 1363.49, SD = 300.86, SVP: off M = 1418.46, SD = 265.41), p = .27, η_p^2 = .047. Although easy task accuracy (p = .34, η_p^2 = .036) and difficult task speed (p = .27, η_p^2 = .047) were also facilitated, the effects were non-significant, **Figure 5, a** and **b.**

Figure 5

Facilitation Driven By Participant's Self-Visual Presence (SVP), Accounting For Difficulty And Performance Screensharing (PSS) Turned Off.



a. Accuracy: SVP **b. RT:** SVP

Error bars +/-1 SE

H1.c: Mutual Co-presence

There was no significant SVP x CVP interaction for accuracy F (1, 26) = 0.029, p = .865, η_p^2 = .001, nor RT F (1, 26) = .733, p = .40, η_p^2 = .027. There was no significant SVP x CVP x Difficulty interaction, for accuracy F (1, 26) = 1.79, p = .192, η_p^2 = .061, nor RT F (1, 26) = 0.51, p = .482, η_p^2 = .019. No follow-up analyses were significant.

H2: Audience Effect (AE)

For the AE, we analysed the individual contribution of effects of self-visual presence (SVP), performance screen-sharing (PSS), and the additive combination of both.

H2.a: Performance Screen Sharing (PSS)

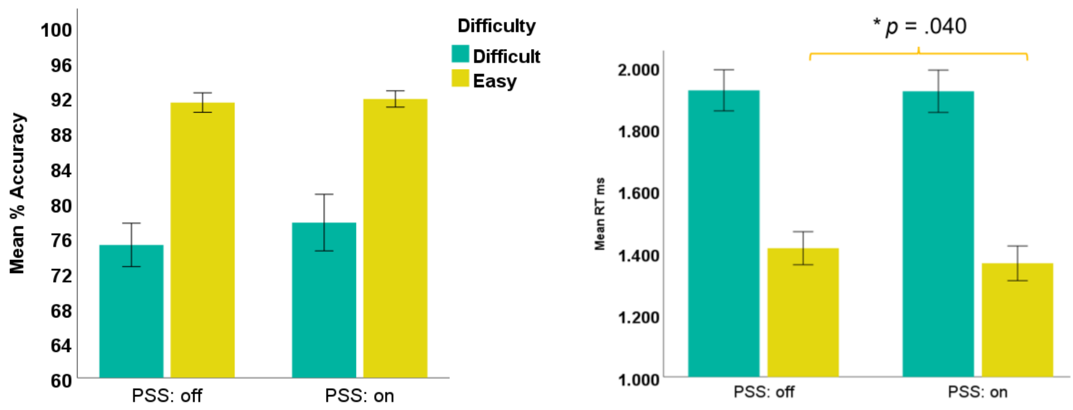
The analysis focused on testing whether performance screen-sharing (PSS) during performance evaluation, irrespective of other channels, would contribute to the AE.

The analysis revealed no main effect of PSS, for accuracy F (1, 26) = 1.82, p = .19, η_p^2 = .065, or *RT*, F (1, 26) = .89, p = .35, η_p^2 = .033. There was no significant PSS x Difficulty interaction either for accuracy F (1, 26) = 1.68, p = .21, η_p^2 = .061, nor RT F (1, 26) = 1.72, p = .20, η_p^2 = .062.

The planned follow-up analyses of PSS, at each Difficulty level separately, revealed that easy task was performed significantly faster when performance was monitored (PSS: on, M = 1366.67, SD = 290.31) versus not monitored (PSS: off, M = 1415.28, SD = 276.49), RT: p = .040, η_p^2 = .153, see **Figure 6**. The difficult task was sped up, but not significantly so.

Figure 6

AE, Performance Screen Sharing (PSS) Contribution Facilitating Easy Task Performance Speed (RT).



a. Accuracy: PSS **b. RT:** PSS

Error bars +/-1 SE

The faster task performance on easy tasks, when monitored, replicates a significant avatar AE finding for RT in the original study (Sutskova, Senju, & Smith, 2022), there we no other effects.

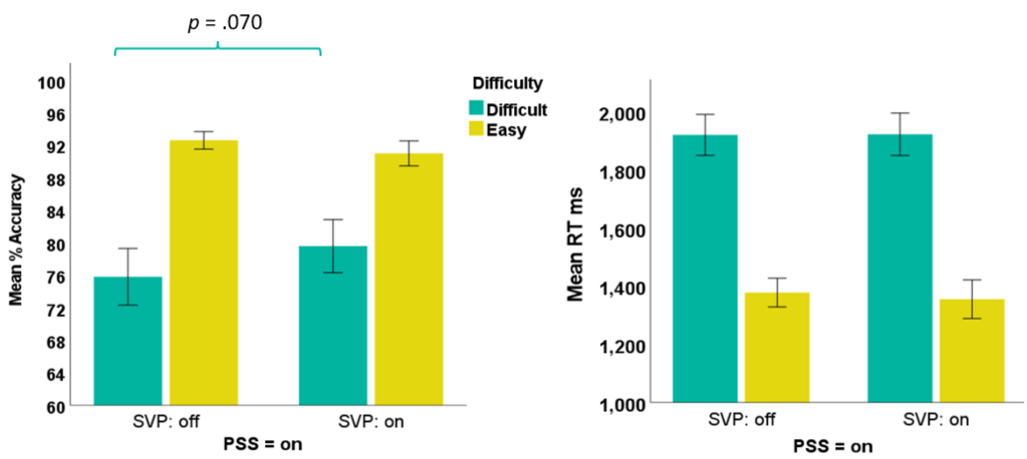
H2.b: Being Visible when Performance Sharing

This analysis investigated whether being self-video seen (SVP: off to SVP: on) whilst performance was monitored would contribute to the AE additionally. There was a marginal PSS x SVP interaction for RT F (1, 26) = 3.053, p = .092, η_p^2 = .105, none for accuracy F (1, 26) = 1.82, p = .189, η_p^2 = .065. The follow-up analyses showed no significant additional contribution of SVP to PSS.

There was a significant PSS x SVP x Difficulty interaction for performance accuracy F (1, 26) = 6.5, p = .017, η_p^2 = .20, and none for *RT F* (1, 26) = .155, p = .70, η_p^2 = .006. Follow-up analyses showed that when screen-sharing was on (PSS: on), having participants be video present (SVP: on) marginally improved accuracy on difficult tasks (SVP: off, M = 75.80, SD = 18.19, SVP: on, M = 79.60, SE = 17.15), p = .070, η_p^2 = .12, **Figure 7**. There were no additional significant contributions of CVP to PSS on difficulty levels.

Figure 7

AE, Self-Visual Presence (SVP) Screen-Sharing (PSS: on), Facilitates Difficult Task Accuracy.



a. Accuracy: PSS + SVP **b. RT:** PSS +SVP

Error bars +/-1 SE

This analysis investigated whether seeing the observer (CVP on) whilst monitored (PSS on) would contribute additionally to the AE. There was no PSS x CVP interaction for accuracy RT F (1, 26) = .001, p = .98, $\eta_p^2 < .001$ or RT F (1, 26) = .471, p = .50, $\eta_p^2 = 0.18$. There was no PSS x CVP x Difficulty interaction for accuracy F (1, 26) = 1.791, p = .192, $\eta_p^2 = .064$ or RT F (1, 26) = .336, p = .567, $\eta_p^2 = 013$**.** The follow-up analyses showed no significant contribution of CVP to PSS.

Table 1

Means (M) and Standard Errors (SE) of Per cent Accuracy (%) All the Levels by Each Factor Within the Experiment Two Design.

Companion Visual Presence	Performance Screen-Sharing	Self-Visual Presence	Difficulty	*M*	*SE*
Off	Off	Off	Easy	90.19	1.63
			Difficult	74.07	2.49
		On	Easy	94.24	1.41
			Difficult	76.85	3.22
	On	Off	Easy	92.41	1.56
			Difficult	77.70	3.56
		On	Easy	91.22	1.43
			Difficult	80.09	3.16
On	Off	Off	Easy	88.66	2.26
			Difficult	73.52	3.62
		On	Easy	92.41	1.40
			Difficult	76.11	3.16
	On	Off	Easy	92.78	1.17
			Difficult	73.89	4.36
		On	Easy	90.74	2.34
			Difficult	79.07	3.96

Table 2

The Means (M) And Standard Errors (SE) Of Reaction Times (RT) For All the Levels by Each Factor Within the Experiment Two Design.

Companion Visual Presence	Performance Screen-Sharing	Self-Visual Presence	Difficulty	*M*	*SE*
Off	Off	Off	Easy	1444.47	62.09
			Difficult	1991.68	83.07
		On	Easy	1396.27	56.03
			Difficult	1868.66	70.90
	On	Off	Easy	1366.60	61.21
			Difficult	1871.65	72.09
		On	Easy	1370.34	63.34
			Difficult	1930.03	83.01
On	Off	Off	Easy	1473.31	66.62
			Difficult	1937.85	82.08
		On	Easy	1347.07	58.35
			Difficult	1899.15	85.12
	On	Off	Easy	1389.46	52.59
			Difficult	1968.81	81.35
		On	Easy	1340.28	78.64
			Difficult	1915.15	82.81

Discussion

This study aimed to understand how the classic social facilitation effect, often reported during in-person encounters, could be elicited through remote videoconferencing. We were interested in whether the ability to perform a cognitive reasoning task remotely could be altered through the two known mechanisms of social facilitation effect: the mere presence effect (MPE), elicited by the co-presence of people in the same environment, and the audience effect (AE), elicited through the feeling of being observed.

We proposed that videoconferencing affordances, such as switching different communication channels on or off, could be a useful tool to disentangle MPE and AE often co-occur during in-person testing. The videoconferencing channels of interest were the participant video self-presence (SVP), companion video visual presence (CVP), and screen-sharing of participant performance to companion (PSS). We have mapped predictions relating to how the videoconferencing channels could elicit the social facilitation effect through the mechanisms, the MPE and AE, based on the perceptual processes reported for each mechanism in the in-person studies.

The first set of hypotheses predicted the impact of videoconferencing channels through the mechanisms of MPE ***(H1)***. We predicted that social facilitation will be elicited through MPE by either the visual video presence of a companion (***H1.a***; companion visual presence: CVP), the visual video presence of participant self to themselves and companion (***H1.b***; self-visual presence: SVP), or an additive effect of the mutual visual video presence of participant and companion to each other (SVP x CVP) — the co-presence (***H1.c***). The results showed that only one channel improved the participants' performance – the SVP, supporting hypothesis *H1. b.* When the participant's self-camera was turned on (SVP on), the performance was marginally faster and significantly more accurate overall. Breaking down effects further by difficulty, as per the canonical social facilitation effect, we found that accuracy significantly improved during difficult tasks, and easy tasks were performed significantly faster. There was no predicted significant CVP or additive effect of CVP on SVP.

The second set of hypotheses predicted the videoconferencing channel impact through the AE pathway ***(H2)***. We predicted that the social facilitation effect could be elicited just through participant performance screen-sharing (PSS) (***H2.a.***), as an additive effect of PSS and participants' self-video presence (SVP), ***H2.b***, or as an additive effect of PSS and companion visibility (CVP), ***H2.c***. The results showed that turning performance screen-sharing on (PSS: on) significantly improved participants' performance speed on easy task responses, offering some support to H2.a. Being additionally visually present (PSS: on x SVP: off vs SVP: on) when screen-sharing performance has marginally improved difficult task accuracy with no additional effect on performance speed, offering some support to H2.b. The CVP had no significant additive effects on PSS. These findings could suggest that knowing your performance is visible to an observer (AE) increases the need to speed up task performance.

Altogether, our results show that being visually present (SVP) during videoconferencing, an effect of MPE in this study, can boost task performance accuracy, irrespective of whether the remote companion sees the performance. Screen-sharing of the task performance (PSS) to a companion, an effect related to AE in this study, speeds up participants' performance on easy tasks. However, it is important to note that there was no significant social facilitation interaction (discussion below).

As discussed previously, the SVP-driven performance change could have been elicited due to the MPE-based mechanisms heightening participants' states of social vigilance, preparedness and self-awareness during co-presence. The heightened social vigilance and self-awareness changes have been previously behaviourally expressed through posture adjustments and more restrictive expressive behaviours, both in contexts when participants believed the camera was on (Kendall et al., 2014; Miller et al., 2017) and when they were co-present alongside a non-attentive confederate during an in-person setting (Guerin, 1983). Heightened self-awareness (objective awareness) through being video present during videoconferencing has previously led to performance improvements (Hassell & Cotton, 2017). The effect could be explained by evoked medium levels of social vigilance that have been previously associated with better task performance (Faller et al., 2019; Khazaei et al., 2021; Yerkes & Dodson, 1908) and with "vigilant-attention" that enables better task focus (Langner & Eickhoff, 2012).

The PSS-driven performance change could be elicited through AE-based mechanisms related to reputation management strategies (Cottrell et al., 1968; Hamilton & Lind, 2016). Why screen-sharing only improved task speed but not accuracy is unclear. But it could be due to the performative nature of AE. Participants could have been attempting to publicly demonstrate their ability to perform the tasks as fast as possible, but succeeded at doing so only on the easy, not the difficult tasks. The public demonstration of task performance competence may be more easily achieved by speeding up performance, rather than focusing on accuracy, which requires more concentration. Therefore, it is possible that increased speed was the easiest route to display task competence, especially for an easier task. By this logic, it could be a manifestation of a reputation management strategy attributed to AE. Additional measures, such as participants' gaze patterns at the task and the companion, as well as qualitative feedback during testing, could have elaborated on this outcome and should be considered in the future.

It is important to note that both MPE (main effect of SVP; H1.b) and AE (PSS on during easy tasks; H2.a) findings in this study replicate our previous videoconferencing MPE and AE results alongside an avatar companion, with a different experimental design (Sutskova, Senju, & Smith, 2022). Therefore, we can conclude that these videoconferencing channels, SVP and PSS, and associated participants' belief of being co-present (MPE) or monitored (AE), alongside an avatar companion, have a significant socially facilitative property to visual cognitive reasoning performance.

Interestingly, similarly to our previous findings, we have not found a negative impact related to the canonical social facilitation effect, in which difficult performance drops in a social setting. Although the RRP cognitive task used in our study has previously been shown to elicit social facilitation during in-person scenarios (Dumontheil et al., 2010, 2016)**.** Considering this, it is possible that videoconferencing is perceived differently than in-person interaction and might not induce as strong a social impact in contrast to when the interaction occurs in-person. Recent research is currently indicating that this might be the case, reporting less social brain synchrony (Bleakley et al., 2022) between people and less physiological (heart rate variability) arousal when interacting through videoconferencing than in-person (Riedl et al., 2023). Heightened threat levels of arousal during social facilitation paradigms are directly associated with detriment to task performance in a cognitive task (Blascovich et al., 1999)**.**

If the lack of task detriment in our videoconferencing studies could be explained by less threatening arousal (vigilance), then videoconferencing could potentially be a less intimidating interaction environment. Videoconferencing could be a sort of "soft social presence" in contrast to in-person encounters. Providing this is the case, arguably, videoconferencing from home could offer a less threatening environment, enabling participants to problem-solve and to be evaluated in a social context with less perceived social stress. Indeed, there is already some evidence that people who struggle with social situations often prefer videoconferencing as a method of communication to lessen stress (O'Neill et al., 2022).

Although the idea of "soft presence" is enticing, it is important to note that the performance changes in our studies are measured in real-time with short-term intervals of around half an hour. Whether remote choices are justified long-term and how they impact peer relations, performance and well-being over time needs to be explored further. For example, learning in a videoconferencing scenario seems to be fatiguing both on brain and the central neural system-based arousal, as measured by EEG and heart-rate variability markers of (Riedl et al., 2023).

It is also important to consider which interaction platform is used during remote task performance and evaluation. We have previously found that the interaction environment types (platforms) and participants' beliefs about them seem to elicit different impacts on participants' ability to perform alongside virtual companions. In one of our prior studies (Sutskova et al., 2023), we found that when applying similar MPE and AE paradigms used in this study within an immersive virtual reality environment, the facilitative effects in videoconferencing were reversed, observing only negative task impact without positive facilitation. The negative impact of immersive environments on cognitive performance is prevalent in social facilitation research (Hoyt et al., 2003; Zanbaka et al., 2004, 2007). We have also shown that participants' performance changes based just on their beliefs of whether they are interacting with an AI-agent or human-driven virtual companions in situations where companions are visually identical, both during videoconferencing (Sutskova et al., 2022) and immersive virtual reality (Sutskova et al., 2023).

Alongside future directions in the field, there are still questions unanswered in the current study paradigm. First of all, in contrast to our predictions that there might be an additive effect of SVP to PSS during AE, and analysis showing a significant PSS x SVP x Difficulty interaction, the post-hoc follow-up analyses found that relations were not additive but rather complementary, see post-hoc analyses in **Appendix A**. The analysis showed that when controlling for performance screen sharing (establishing clear no performance monitoring, PSS: off), turning participants' SVP from off to on additionally significantly improved difficult tasks' performance speed. Therefore, it is worth noting that there might be an interaction (or a trade-off) between SVP and PSS. The relation might not be additive but rather complementary, and should be explored further.

We would recommend future studies expanding on this effect with a repeated-measures design to increase their sample size when more complex relationships are sought. Although our analysis detected a significant SVP x PSS x Difficulty interaction, it is possible that more complex four-way interactions relating to difficulty and levels of presence were underpowered.

Furthermore, the AE manipulation in this study (driven by PSS) replicated the effect alongside the avatar companion in our previous study (Sutskova et al., 2022). It is, however, important to note that previously we found that realistic and avatar videoconferencing companions impacted participants' performance differently during AE. The monitoring by video of a companion facilitated participants' difficult task accuracy, similarly to MPE, whilst the avatar only improved easy task speed. Considering there were no companion visibility (CVP) effects in this study, it seemed that the effect was driven by overall interaction with the avatar, irrespective of whether they could be seen (or not) during testing later on. It is important to investigate these effects further using a live video feed of the researcher for the CVP condition instead of the animated avatar used here. It is possible that because the synchronous artificial avatar companion did not show any photo-realistic facial expressions or behaviours, the participants were not as interested in the companion's visual presence (hence no CVP effect). However, it is also possible that just the context of the avatar overall changed the performance trajectory, at least for AE (similarly to Sutskova et al., 2022). Future research should explore this paradigm, contrasting realistic and virtual companion presence impact on performance, alongside gaze tracking to monitor participants' attention shifts and duration distribution on the task, self or the companion during the study. This research is currently underway.

Finally, the notion of what social co-presence entails and how it is perceived throughout the interaction platforms needs to be more clearly defined and established in the field, both theoretically and empirically. As discussed previously, co-presence is a rudimentary building block of social cognition (Campos-Castillo & Hitlin, 2013), yet there are many levels of "social presence" depending on the definition and the field (Lee, 2004b). In this study, we investigated MPE through the visual presence of self and companion on the same platform. However, presence could be potentially established through audio channels, synchronicity of interaction, identification, and even by simply being logged in to the same messenger together with all other channels off. More work needs to be done to understand how these channels (factors) engage the brain and relevant cognitive and affective processes in the social interactive space. Importantly, as we found before, participants' beliefs about interactions seem to be a powerful influence over the performance outcomes as well (Sutskova et al., 2022). Considering technology can occlude communication channels, helping to reinforce some beliefs, remote communication technologies could be fascinating tools to understand how beliefs and communication platforms come together to shape social perception and its effects in a systematic and ecologically valid way.

In conclusion, we found that being visible on the video to a companion whilst performing a cognitive task can boost task accuracy, whilst screen-sharing performance improves the speed at which it is performed. There were no significant negative impacts on performance. These video channels could be applied in classroom and work settings in which short-term task facilitation without too much social pressure might be advantageous. More research needs to be done on the long-term effects of such interaction on the brain, behaviour, performance and overall participants' wellbeing. Our experiments offer a preview into how classic effects used in psychology for over a century can be reinvigorated in the new era of technology-augmented social reality. This symbiosis of classic effects and digitally augmented communication allows us to learn more about the generalisability of the processes involved in the classic effects and how emergent technologies engage the brain, behaviour and performance.

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Statements and Declarations

NA

Ethical Considerations

The study was approved by the Birkbeck University of London, Psychology Department Ethics Committee, approval number: 192084.

Consent to Participate

The participants were given information about the study and signed the consent form provided on the online experimental platform (Gorilla.sc). Participants had the right to withdraw their consent and data at any time during the study.

Consent to Publish

Participants were made aware that the research data would be published (anonymised) and consented to the dissemination.

Declaration of Conflict of Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Data Availability

The anonymised research data will be publicly available on the OSF page: https://osf.io/tw46x/files/fb6kp, upon acceptance of this publication.

The avatar companion metadata file is uploaded to the OSF page: https://osf.io/tw46x/files.

References

Aiello, J. R., & Kolb, K. J. (1995). Electronic Performance Monitoring and Social Context: Impact on Productivity and Stress. In *Journal of Applied Psychology* (Vol. 80, Issue 3).

Blascovich, J., Mendes, W. B., Hunter, S. B., & Salomon, K. (1999). Social Facilitation As Challenge and Threat. *Journal of Personality and Social Psychology*, *77*(1), 68–77. https://doi.org/10.1037/0022-3514.77.1.68

Bleakley, A., Rough, D., Edwards, J., Doyle, P., Dumbleton, O., Clark, L., Rintel, S., Wade, V., & Cowan, B. R. (2022). Bridging social distance during social distancing: exploring social talk and remote collegiality in video conferencing. *Human–Computer Interaction*, *37*(5), 404–432. https://doi.org/10.1080/07370024.2021.1994859

Bond, C. F. (1982). Social facilitation: A self-presentational view. *Journal of Personality and Social Psychology*, *42*(6), 1042–1050. https://doi.org/10.1037/0022-3514.42.6.1042

Bond, C. F., & Titus, L. J. (1983). Social facilitation: A meta-analysis of 241 studies. *Psychological Bulletin*, *94*(2), 265–292. https://doi.org/10.1037/0033-2909.94.2.265

Campos-Castillo, C., & Hitlin, S. (2013). Copresence. *Http://Dx.Doi.Org/10.1177/0735275113489811*, *31*(2), 168–192. https://doi.org/10.1177/0735275113489811

Cañigueral, R., Krishnan-Barman, S., De, A. F., & Hamilton, C. (2022). Social signalling as a framework for second-person neuroscience. *Psychonomic Bulletin & Review 2022*, *1*, 1–13. https://doi.org/10.3758/S13423-022-02103-2

Chevallier, C., Parish-Morris, J., Tonge, N., Le, L., Miller, J., & Schultz, R. T. (2014). Susceptibility to the audience effect explains performance gap between children with and without autism in a Theory of Mind task. *Journal of Experimental Psychology. General*, *143*(3), 972. https://doi.org/10.1037/A0035483

Cottrell, N. B., Wack, D. L., Sekerak, G. J., & Rittle, R. H. (1968). Social facilitation of dominant responses by the presence of an audience and the mere presence of others. In *Journal of Personality and Social Psychology* (Vol. 9, Issue 3, pp. 245–250). American Psychological Association. https://doi.org/10.1037/h0025902

Dumontheil, I., Houlton, R., Christoff, K., & Blakemore, S. J. (2010). Development of relational reasoning during adolescence. *Developmental Science*, *13*(6). https://doi.org/10.1111/J.1467-7687.2010.01014.X

Dumontheil, I., Wolf, L. K., & Blakemore, S. J. (2016). Audience effects on the neural correlates of relational reasoning in adolescence. *Neuropsychologia*, *87*, 85–95. https://doi.org/10.1016/j.neuropsychologia.2016.05.001

Faller, J., Cummings, J., Saproo, S., & Sajda, P. (2019). Regulation of arousal via online neurofeedback improves human performance in a demanding sensory-motor task. *Proceedings of the National Academy of Sciences of the United States of America*, *116*(13), 6482–6490. https://doi.org/10.1073/pnas.1817207116

George, J., Mirsadikov, A., Nabors, M., & Marett, K. (2022). What do Users Actually Look at During 'Zoom' Meetings? Discovery Research on Attention, Gender and Distraction Effects.

Proceedings of the 55th Hawaii International Conference on System Sciences. https://doi.org/10.24251/HICSS.2022.582

Grant, T., & Dajee, K. (2003). Types of task, types of audience, types of actor: interactions between mere presence and personality type in a simple mathematical task. *Personality and Individual Differences*, *35*(3), 633–639. https://doi.org/10.1016/S0191-8869(02)00241-6

Guerin, B. (1983). Social facilitation and social monitoring: A test of three models. *British Journal of Social Psychology*, *22*(3), 203–214. https://doi.org/10.1111/J.2044-8309.1983.TB00585.X

Guerin, B. (1986). Mere presence effects in humans: A review. *Journal of Experimental Social Psychology*, *22*(1), 38–77. https://doi.org/10.1016/0022-1031(86)90040-5

Guerin, B., & Innes, J. M. (1982). Social facilitation and social monitoring: A new look at Zajonc's mere presence hypothesis. *British Journal of Social Psychology*, *21*(1), 7–18. https://doi.org/10.1111/J.2044-8309.1982.TB00506.X

Guerin, B., & Innes, J. M. (1984). Explanations of social facilitation: A review. *Current Psychological Research & Reviews*, *3*(2), 32–52. https://doi.org/10.1007/BF02686548

Hamilton, A. F. de C., & Lind, F. (2016). Audience effects: what can they tell us about social neuroscience, theory of mind and autism? *Culture and Brain*, *4*(2), 159–177. https://doi.org/10.1007/s40167-016-0044-5

Hassell, M., & Cotton, J. L. (2017). The consequences of seeing oneself on camera: Toward improved virtual team performance. *Https://Doi.Org/10.5465/Ambpp.2016.17840abstract*, *2016*(1), 17840. https://doi.org/10.5465/AMBPP.2016.17840ABSTRACT

Hoyt, C. L., Blascovich, J., & Swinth, K. R. (2003). Social Inhibition in Immersive Virtual Environments. *Presence: Teleoperators and Virtual Environments*, *12*(2), 183–195. https://doi.org/10.1162/105474603321640932

Joinson, A. N. (2001). Self-disclosure in computer-mediated communication: The role of self-awareness and visual anonymity. In *European Journal of Social Psychology Eur. J. Soc. Psychol* (Vol. 31).

Kawase, S. (2009). An exploratory study of gazing behavior during live performance. *ESCOM 2009 : 7th Triennial Conference of European Society for the Cognitive Sciences of Music*. https://jyx.jyu.fi/handle/123456789/20882

Kendall, W., Chan, K., & Kingstone, A. (2014). The effect of camera presence on arousal, attentional control and inhibition. *Journal of Vision*, *14*(10), 646–646. https://doi.org/10.1167/14.10.646

Khazaei, S., Amin, M. R., & Faghih, R. T. (2021). Decoding a Neurofeedback-Modulated Cognitive Arousal State to Investigate Performance Regulation by the Yerkes-Dodson Law. *Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Annual International Conference*, *2021*, 6551–6557. https://doi.org/10.1109/EMBC46164.2021.9629764

Langner, R., & Eickhoff, S. B. (2012). Sustaining Attention to Simple Tasks: A Meta-Analytic Review of the Neural Mechanisms of Vigilant Attention. *Psychological Bulletin*, *139*(4), 870. https://doi.org/10.1037/A0030694

Lee, J. E. R., Nass, C. I., & Bailenson, J. N. (2014). Does the mask govern the mind?: Effects of arbitrary gender representation on quantitative task performance in avatar-represented virtual groups. *Cyberpsychology, Behavior, and Social Networking*, *17*(4), 248–254. https://doi.org/10.1089/CYBER.2013.0358;JOURNAL:JOURNAL:CYBER;ISSUE:ISSUE:10.1089/CYBER.2014.17.ISSUE-4;WGROUP:STRING:PUBLICATION

Lee, J.-E. R. (2009). *To Reveal or To Cloak? Effects of Identity Salience on Stereotype Threat Responses in Avatar-Represented Group Contexts*. *4*(1), 34–49.

Lee, K. M. (2004). Presence, Explicated. *Communication Theory*, *14*(1), 27–50. https://doi.org/10.1111/J.1468-2885.2004.TB00302.X

Lyyra, P., Astikainen, P., & Hietanen, J. K. (2018). Look at them and they will notice you: Distractor-independent attentional capture by direct gaze in change blindness. *Visual Cognition*, *26*(1), 25–36. https://doi.org/10.1080/13506285.2017.1370052

Manning, J. M. (2020). Professionalism. *The Path to Building a Successful Nursing Career*, 147–171. https://doi.org/10.1007/978-3-030-50023-8_9

Mennecke, B. E., Triplett, J. L., Hassall, L. M., & Conde, Z. J. (2010). Embodied Social Presence Theory. *2010 43rd Hawaii International Conference on System Sciences*, 1–10. https://doi.org/10.1109/HICSS.2010.179

Miller, M. K., Mandryk, R. L., Birk, M. V., Depping, A. E., & Patel, T. (2017). Through the looking glass: Effects of feedback on self-awareness and conversation during video chat. *Conference on Human Factors in Computing Systems - Proceedings*, *2017-May*, 5271–5283. https://doi.org/10.1145/3025453.3025548

O'Neill, D. K., Reinhardt, S., & Jayasundera, K. (2022). What undergraduates say about choosing an online or in-person course: qualitative results from a large-sample, multi-discipline survey. *Higher Education Research & Development*, *41*(4), 1199–1214. https://doi.org/10.1080/07294360.2021.1896484

Ozono, S., Schindler, C., Nakamura, Y., Arakawa, Y., & Minker, W. (2025). *How Do Bias Strategies and Appearance Shape Avatar Preferences?: Toward the Development of Avatars for Health Support*. https://arakawa-lab.com

Puce, A., & Perrett, D. (2003). Electrophysiology and brain imaging of biological motion. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *358*(1431), 435–445. https://doi.org/10.1098/rstb.2002.1221

Rajecki, D. W. (2010). Zajonc, Cockroaches, and Chickens, c. 1965—1975: A Characterization and Contextualization. *Emotion Review*, *2*(4), 320–328. https://doi.org/10.1177/1754073910375477

Rajecki, D. W., Ickes, W., Corcoran, C., & Lenerz, K. (1977). Social Facilitation of Human Performance: Mere Presence Effects. *The Journal of Social Psychology*, *102*(2), 297–310. https://doi.org/10.1080/00224545.1977.9713277

Redcay, E., & Schilbach, L. (2019). Using second-person neuroscience to elucidate the mechanisms of social interaction. *Nature Reviews. Neuroscience*, *20*(8), 495. https://doi.org/10.1038/S41583-019-0179-4

Richards, J. M., & Gross, J. J. (1999). Composure at Any Cost? The Cognitive Consequences of Emotion Suppression. *Http://Dx.Doi.Org/10.1177/01461672992511010*, *25*(8), 1033–1044. https://doi.org/10.1177/01461672992511010

Riedl, R., Kostoglou, K., Wriessnegger, S. C., & Müller-Putz, G. R. (2023). Videoconference fatigue from a neurophysiological perspective: experimental evidence based on electroencephalography (EEG) and electrocardiography (ECG). *Scientific Reports*, *13*(1), 18371. https://doi.org/10.1038/S41598-023-45374-Y

Sanders, G. S. (1981). Driven by distraction: An integrative review of social facilitation theory and research. *Journal of Experimental Social Psychology*, *17*(3), 227–251. https://doi.org/10.1016/0022-1031(81)90024-X

Sanders, G. S., Baron, R. S., & Moore, D. L. (1978). Distraction and social comparison as mediators of social facilitation effects. *Journal of Experimental Social Psychology*, *14*(3), 291–303. https://doi.org/10.1016/0022-1031(78)90017-3

Schilbach, L., Timmermans, B., Reddy, V., Costall, A., Bente, G., Schlicht, T., & Vogeley, K. (2013). Toward a second-person neuroscience. *Behavioral and Brain Sciences*, *36*(04), 393–414. https://doi.org/10.1017/S0140525X12000660

Schmitt, B. H., Gilovich, T., Goore, N., & Joseph, L. (1986). Mere presence and social facilitation: One more time. *Journal of Experimental Social Psychology*, *22*(3), 242–248. https://doi.org/10.1016/0022-1031(86)90027-2

Somerville, L. H., Jones, R. M., Ruberry, E. J., Dyke, J. P., Glover, G., & Casey, B. J. (2013). The Medial Prefrontal Cortex and the Emergence of Self-Conscious Emotion in Adolescence. *Psychological Science*, *24*(8), 1554–1562. https://doi.org/10.1177/0956797613475633

Strojny, P. M., Dużmańska-Misiarczyk, N., Lipp, N., & Strojny, A. (2020). Moderators of Social Facilitation Effect in Virtual Reality: Co-presence and Realism of Virtual Agents. *Frontiers in Psychology*, *11*, 1252. https://doi.org/10.3389/FPSYG.2020.01252/BIBTEX

Sundaram, D. S., & Webster, C. (2000). The role of nonverbal communication in service encounters. *Journal of Services Marketing*, *14*(5), 378–391. https://doi.org/10.1108/08876040010341008/FULL/PDF

Sutskova, O., Senju, A., & Smith, T. J. (2022). Impact of Video-Mediated Online Social Presence and Observance on Cognitive Performance. *Technology, Mind, and Behavior*, *3*(2: Summer 2022). https://doi.org/10.1037/TMB0000023

Sutskova, O., Senju, A., & Smith, T. J. (2023). Cognitive Impact of Social Virtual Reality: Audience and Mere Presence Effect of Virtual Companions. *Human Behavior and Emerging Technologies*, *2023*. https://doi.org/10.1155/2023/6677789

Williams, E. H., Cristino, F., & Cross, E. S. (2019). Human body motion captures visual attention and elicits pupillary dilation. *Cognition*, *193*, 104029. https://doi.org/10.1016/J.COGNITION.2019.104029

Wolf, L. K., Bazargani, N., Kilford, E. J., Dumontheil, I., & Blakemore, S. J. (2015). The audience effect in adolescence depends on who's looking over your shoulder. *Journal of Adolescence*, *43*, 5–14. https://doi.org/10.1016/j.adolescence.2015.05.003

Yee, J., Lee, J., Desowitz, A., & Blumstein, D. T. (2013). The Costs of Conspecifics: Are Social Distractions or Environmental Distractions More Salient? *Ethology*, *119*(6), 480–488. https://doi.org/10.1111/ETH.12085

Yerkes, R. M., & Dodson, J. D. (1908). The relation of strength of stimulus to rapidity of habit-formation. *Journal of Comparative Neurology and Psychology*, *18*(5), 459–482. https://doi.org/10.1002/cne.920180503

Zajonc, R. B. (1965). Social Facilitation. *Science*, *149*(3681), 269–274. https://doi.org/10.2307/1715944

Zanbaka, C. A., Ulinski, A. C., Goolkasian, P., & Hodges, L. F. (2004). *Effects of Virtual Human Presence on Task Performance*. https://www.semanticscholar.org/paper/Effects-of-Virtual-Human-Presence-on-Task-Zanbaka-Ulinski/c53b72312cd2802b7176b6171528fce0fe0e7ebb

Zanbaka, C. A., Ulinski, A. C., Goolkasian, P., & Hodges, L. F. (2007). Social responses to virtual humans. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems - CHI '07*, 1561. https://doi.org/10.1145/1240624.1240861

Appendix A

MPE (explorative): Self-Presence with Performance Screen Sharing Off

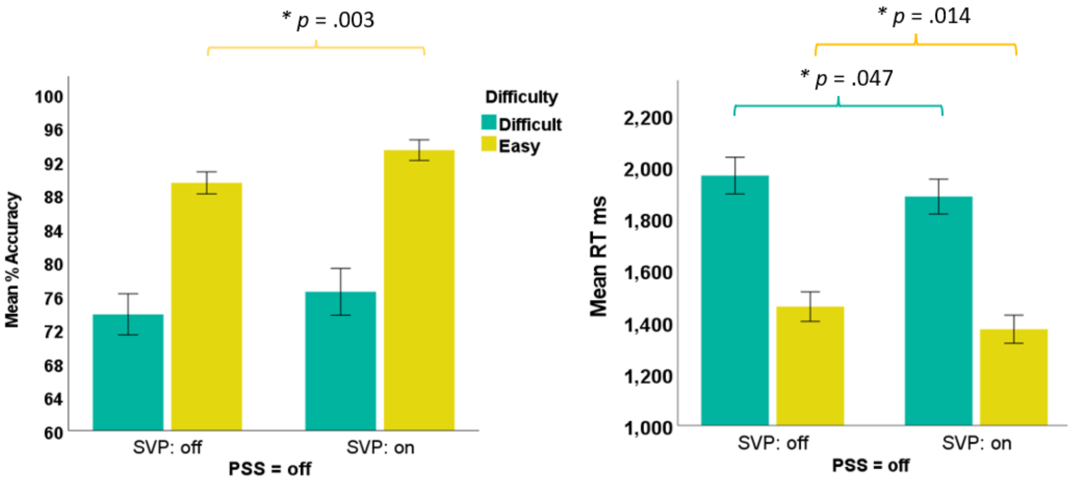
Explorative post-hoc analysis focused on the PSS x SVP x difficulty interaction, only when the PSS level is off. This analysis could not have been performed in experiment one as the attentive monitoring and non-attentive co-presence were not experimentally parsed.

Accuracy. The significant PSS x SVP x difficulty interaction, F (1, 26) = 6.5, p = .017, η_p^2 = .20, was broken down by each difficulty level separately (PSS x SVP for easy and difficult conditions), contrasting the SVP when performance was not seen (PSS: off). There was a significant PSS x SVP interaction for easy task accuracy, F (1, 26) = 6.37, p = .018, η_p^2 = .197. The exploratory analyses demonstrated that when PSS was off, the easy task accuracy improved significantly, p = .003, η_p^2 = .29, by turning SVP on (M = 93.32, SD = 6.24) in contrast to when the SVP was off (M = 89.42, SD = 6.75). There was no SFE-related impact (**Figure A. 1. a)**.

Reaction Times. There was a marginal PSS x SVP interaction, F (1, 26) = 3.05, p = .092, η_p^2 = .105, and no significant PSS x SVP x difficulty interaction, F (1, 26) = .336, p = .57, η_p^2 =.013. As per canonical effects analysis, the PSS x SVP interaction was still broken down within each difficulty level (easy, difficult) separately. The analyses revealed that when performance was not monitored by companion (PSS: off), having self-video presence on (SVP: on) significantly improved the speed of accurate responses, both for easy (SVP: off, M = 1458.89, SD = 296.49, SVP: on, M = 1371.67, SD = 282.77), and difficult (SVP: off, M = 1964.77, SD = 367.00, SVP: on, M = 1883.91, SE = 349.39) tasks, easy p = .014, η_p^2 = .21, difficult p = .047, η_p^2 = .143, **Figure A.1.b.**

Figure A. 1

Self-Video Presence (SVP) Facilitation Under the Assurance Performance Screensharing (PSS) Was Off.



a. Accuracy: SVP with PSS: off

b. RT: SVP with PSS: off