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Social anxiety in online social interactions: Examining the effects of self and audience images on anxiety, self-awareness and performance evaluations

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ABSTRACT

Background: Few studies have examined social anxiety symptoms during online social interactions. We examined self-report symptoms in individuals with elevated social anxiety in online interactions in the presence/absence of virtual audience images and the presence/absence of live videos of the self.
Method: Participants with elevated social anxiety who were not treatment-seeking gave a short impromptu talk via an online social communication platform. Participants were randomised to present with their camera on or off, and to audience images that were visible or not. We recorded participants' self-reported anxiety, perspective taken, evaluations of speech performance, and post-event processing.
Results: Anxiety increased during the online social interaction. Furthermore, participants whose camera was on, but the audience was not visible, evaluated their own performance as worse and engaged in more severe negative post-event processing compared with the other conditions.
Discussion: Online videoconferencing tasks can induce anxiety and activate negative self-images and post-event evaluations of social performance. Our findings support the use of online social interactions to research social anxiety, maladaptive cognitive-behavioural biases and to develop novel interventions.

1. Introduction

Social anxiety disorder (SAD) is characterised by long term, intense and persistent fear, and avoidance of social situations (American Psychiatric Association, 2022). Cognitive models of social anxiety highlight several biases in self-focus, self-image and attention that increase anxiety and negative beliefs during social interactions, and that bias post-event evaluations of social performance (Clark & Wells, 1995; Rapee & Heimberg, 1997). During the social interaction, individuals attend to salient aspects of their audience (e.g., facial expressions that signal disapproval) and self-focus - an inward-directed attention on physical symptoms, anxious thoughts, and how they are perceived by others. This self-focus generates a self-image of themselves as a 'social object' – a negative visual image taken from the perspective of their audience, so called 'observer perspective', that characterises feared observable deficits in social performance and anxiety (e.g., stuttering speech, blushing and nervousness). This observer perspective, triggered by the felt presence of the audience, limits processing resources during the interaction, biases post-event evaluations of social performance and maintains fears of negative evaluation and social anxiety (Heimberg et al., 2010; Schultz & Heimberg, 2008).

Extensive research supports the importance of self-focus and self-image (Norton & Abbott, 2016) – both subclinical and clinical social anxiety populations report increased self-focus during socially evaluative situations (Alden & Mellings, 2004; Meral & Vriends, 2022; Perowne & Mansell, 2002). Self-focused attention correlates with levels of trait social anxiety (Holzman et al., 2014; Hutchins et al., 2021) and state social anxiety/fear (Chen et al., 2013; Tomita et al., 2019). Experimental manipulations of self-focus can also increase and decrease social anxiety (see Bögels and Mansell 2004 for a review). Consequently, self-focus and negative self-imagery taken from the observer perspective are therapeutic targets in current first-line cognitive-behavioural treatments for social anxiety.

The negative self-image is in part triggered by a sense of self as social object – an awareness of being observed by others. The felt sense of audience and social evaluation occurs across social interactions, with social anxiety greatest in situations that are explicitly self-referential (e.g., getting to know someone new) or evaluative (e.g., interview or

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delivering a performance) (Dickerson, 2008). Attention to the audience, and in particular cues that signal social disapproval (e.g., negative facial expressions) increase the salience and negativity of the self-image (Dickerson & Kemeny, 2004). Several features of the audience can increase social anxiety further, including the perceived audience status/-importance (and corresponding consequences of negative evaluation), the duration and consistency of negative cues, and audience size (Bantin et al., 2016; Chen, van den Bos, et al., 2020; Heimberg et al., 2014).

There is evidence that individuals with social anxiety attend to external social cues (see Bantin et al. 2016 for a review), and interpret neutral/ambiguous cues as threatening (Amin et al., 1998; Bell et al., 2011; Bourke et al., 2012; Chen et al., 2019; Garner et al., 2009; Stopa & Clark, 2000). Resources are further consumed by attentional biases to somatic interoceptive symptoms of anxiety (e.g., increased heart rate and skin temperature) (Deiters et al., 2013; Mansell et al., 2003; Mills et al., 2014; Pineles & Mineka, 2005) that further distort the self-image during the social interaction and bias post-event evaluations of performance.

In recent years social communication and interactions have moved online – presenting new social challenges for individuals with social anxiety. Meetings at work, educational teaching and assessment, and social lives play-out across a range of online platforms (e.g., Teams, Zoom). How individuals with social anxiety experience online interactions is not clear. While online interactions do not provide the physical proximity of non-digital interactions, they do provide opportunities for maladaptive cognitive-behavioural biases to exacerbate and maintain social anxiety. For example, online environments can feature a 'high perceptual load' comprising live audience images, profile pictures, emoticons, text chat and images of oneself. How these features influence anxiety, self-image, observer perspective and post-event processing biases have not been examined in experimental designs that manipulate audience visibility and videos of the self. Initial findings suggest social anxiety and self-focus can be activated during online video communications in individuals with subclinical and clinical levels of social anxiety (Huneke et al., 2022; Miller et al., 2021; Vriends et al., 2017), though reported anxiety is lower compared to in-person social interactions (Markovitzky et al., 2012; Yen et al., 2012). By extension, established cognitive behavioural models might predict that social anxiety will increase in online interactions when the audience is visible and individuals can scrutinise cues that signal social disapproval, strengthening their negative self-image from an observer-perspective. Anxious individuals may adopt a range of safety-behaviours, including looking away from the screen, or turning off their own camera (Azriel et al., 2020). As has been shown in real-life social interactions, avoidance and safety-behaviours are problematic – they prevent the processing of information that can correct dysfunctional beliefs and maintain social-evaluative concerns (Clark & Wells, 1995). However, online interactions typically encourage individuals to display their own camera image to their audience, providing live visual feedback that may be negatively interpreted and exacerbate anxiety further in socially anxious individuals. However, as part of therapeutic cognitive-behavioural exercises, the live feedback may be helpful, enabling anxious individuals to test and correct negative self-images (from an observer-perspective). Consequently, a better understanding of how features of online social interactions can increase and decrease social anxiety could provide new opportunities to target cognitive-behavioural biases in social anxiety as part of accessible and cost-effective online therapeutic interventions.

In the current study, we modified a public speaking protocol (Kirschbaum et al., 1993; McNair et al., 1982; Osório et al., 2008) to examine social anxiety during an online performance task. Individuals with elevated levels of social anxiety were randomised to one of four between-subjective conditions in which they presented to audience members who were visible (cameras and profile pictures on) or not, while having their own camera either off, or on and visible to themselves and their audience. We measured participant's self-report anxiety throughout the session, and self-image, perspective and ratings of their social performance from their own perspective (self-referent) and the perspective of their audience (other-referent). We also measured performance ratings from independent observers.

We predicted that the online social stressor would increase anxiety prior to and during the presentation, and that individuals would experience most anxiety when presenting with their camera on to a visible audience. Similarly, we predicted that individuals would adopt a strong negative self-image from an observer perspective, report greater awareness of themselves and their audience, and be most critical of their social performance (post-event) when presenting with their camera on to a visible audience. We predicted the combination of presenting with camera on to a visible audience would most exacerbate these features of social anxiety for two reasons. Firstly, a visible audience is more salient and likely to activate a stronger felt-sense of being observed and evaluated. Second, displaying their participant camera enables the audience to witness 'observable deficits in social performance' that are feared in social anxiety, and that are incorporated in the anxiety-provoking negative self-image taken from the observer perspective. Consistent with cognitive-behavioural models (Clark & Wells, 1995; Rapee & Heimberg, 1997), we predicted positive associations between anxiety, observer perspective taking, and negative self-evaluations and post-event processing.

2. Method

Data were collected between March 2021 and February 2022. Participants provided informed consent prior to the pre-screening and the videoconferencing sessions. Ethics approval was granted by the University of Southampton Research Ethics and Governance Committee (reference #57202). Participants received £ 6.50 (via Prolific) or course credits (for students) upon completion.

2.1. Participants

Participants were recruited from the local community and the public and were eligible if they met the following inclusion criteria: (a) aged 18–55 years; (b) use of computer with webcam and microphone (c) a score of 15 or more on the Social Phobia Inventory (SPIN) (Connor et al., 2000), (d) fluent English. No additional exclusionary criteria were used.

We report data from 121 participants (84 females, M_{age} = 32.61, SD_{age} = 9.99). Data were lost from 12 participants due to technical difficulties during the online session (e.g., microphone problems), and three participants were non-compliant with the videoconferencing instructions (e.g., other individuals/pets interacted with them during the session).

In a 2 × 2 between-subjects design, participants were randomised to present with their camera on or off, and to audience images that were on or off.

2.2. Materials

2.2.1. Virtual audience

Fig. 1 presents two of the four computer screen displays used - 'audience on/speaker on' (top panel) and 'audience off/speaker off' (bottom panel) conditions. In each condition, the experimenter (first author) was initially joined by an audience of five 'dummy' individual profiles [4 visible profiles plus 2 hidden - see top left panel Fig. 1). A further 15 audience members joined the session for the presentation (middle panel Fig. 1). At the end of the session, 15 of the 20 dummy audience members left the online session (right panel Fig. 1). These profile images were selected to convey typical neutral/smiling expressions commonly seen in social media profiles.

2.2.2. Screening

Participants completed the Social Phobia Inventory SPIN (Connor

Fig. 1. *The Experimental Protocol and Example Screenshots from the Online Videoconferencing Session. Note.* PHQ-9 (Patient Health Questionnaire-9), GAD-7 (Generalised Anxiety Disorder Assessment), PRCA-24 (The Personal Report of Communication Apprehension), R-GPTS (The Revised Green et al. Paranoid Thoughts Scale), SUDS (Subjective Units of Distress Scale), SASCI (Social Anxiety Session Change Index), SPS (Speech Performance Scale), TQ (Thoughts Questionnaire), AI (Artificial Intelligence). Top three figures (online interaction interface) depict session with both dummy audience images (Audience) and participant video (Speaker) are on. Bottom three figures depict session with both audience images (Audience) and participant video (Speaker) off. Interface reconstructed for demonstration purposes.

et al., 2000). The SPIN consists of 17 items that assess the spectrum of SAD on the dimensions of fear (e.g., of being criticised), avoidance (e.g., of making speeches), and physiological unpleasantness (e.g., heart palpitations). It is rated on a five-point Likert-type scale (0 = not at all, 4 = extremely). The SPIN is widely used as a screening tool in social anxiety research, with scores > 15 indicative of elevated social anxiety (Connor et al., 2000).

2.2.3. Baseline measures

Participants completed the following baseline measures of mental health and wellbeing: Generalized Anxiety Disorder screener - GAD-7 (Spitzer et al., 2006); Patient Health Questionnaire, PHQ-9 (Kroenke & Spitzer, 2002) to assess depressive symptoms; Personal Report of Communication Apprehension - public speaking sub scale, PRCA-24 (McCroskey, 2015), to measure communication apprehension levels when performing in public; and the Revisited Green Paranoid Thoughts Scale - Persecutory Paranoia Subscale, R-GPTS; (Freeman et al., 2019), to explore paranoia levels. All these measures showed good psychometric properties in our sample (see Table 1 notes), consistent with levels reported in previous studies (alphas >.87) for GAD-7, PHQ-9, PRCA-24, R-GPTS-PP (Beard et al., 2016; Freeman et al., 2019; Löwe et al., 2008; McCroskey et al., 1985).

2.2.4. Primary outcome measures

2.2.4.1. Subjective units of distress (SUDS). To measure state anxiety during the social interaction we asked participants to rate 'How anxious do you feel right now?' on a visual analogue scale, ranging from 0 being 'not at all' to 100 being 'extremely anxious' (Wolpe, 1990).

2.2.4.2. Social anxiety session change index ($SASCI_{Modified}$). Participants rated their state social anxiety using the Social Anxiety Session Change Index (SASCI) (Hayes et al., 2008). SASCI is a four-item instrument that has been developed to monitor therapy progress for clinicians and rated on a seven-point Likert-type scale, ranging from 1 (much less than at the start of treatment) to 4 (not different from at the start of treatment) to 7 (much more than at the start of treatment). We used the following four modified items: (1) How keen are you to avoid this situation? (2) Are you concerned about being the centre of attention (and interacting with people)? (3) How embarrassed are you feeling? (4) How concerned are

Table 1
Baseline Group Characteristics.

Analysis Sample ($N = 121$)									
	Audience ON, Speaker (Camera) ON n = 29		Audience ON, Speaker (Camera) OFF n = 29		Audience OFF, Speaker (Camera) ON n = 32		Audience OFF, Speaker (Camera) OFF n = 31		
Variable	M	*SD*	M	*SD*	M	*SD*	M	*SD*	Test
Age	30.28	9.52	35.10	10.28	30.28	9.54	34.87	9.99	Welch's F (3, 64.69) = 2.26, p = .089
PHQ-9	7.38	5.71	7.07	5.08	7.31	5.91	8.65	7.04	Welch's F (3, 64.78) = 0.35, p = .789
SPIN	30.45	12.04	28.72	10.21	33.88	10.62	28.55	9.28	Welch's F (3, 64.36) = 1.77, p = .161
GAD-7	11.41	8.24	11.48	6.31	12.09	7.21	10.77	6.83	Welch's F (3, 64.54) = 0.18, p = .907
PRCA-24	22.07	4.80	22.97	3.65	22.01	4.93	21.16	3.63	Welch's F (3, 64.37) = 1.20, p = .316
R-GPTS	3.90	6.61	4.39	7.33	7.19	7.36	4.55	5.82	Welch's F (3, 64.45) = 1.26, p = .296
Videoconferencing Experience (0−10)	5.72	2.45	6.07	2.49	5.62	2.14	5.45	2.03	Welch's F (3, 64.18) = 0.37, p = .776
AI Knowledge (0−4)	1.01	0.80	1.07	0.65	1.34	0.91	1.39	1.09	Welch's F (3, 64.47) = 1.44, p = .240
	n	%	n	%	n	%	n	%	
Gender (Female)	24	83	23	79	17	53	20	65	Fisher's Exact Test, p = .067
Ethnicity (White)	21	72	23	79	20	62	22	71	Fisher's Exact Test, p = .828

Note. PHQ −9 (Patient Health Questionnaire-9), SPIN (The Social Phobia Inventory), GAD-7 (Generalised Anxiety Disorder Assessment), PRCA-24 (The Personal Report of Communication Apprehension), R-GPTS (The Revised Green et al. Paranoid Thoughts Scale), AI (Artificial Intelligence). For PRCA-24 and R-GPTS the subscales of Public Speaking and Persecutory Paranoia were used, respectively. Degrees of freedom (df) were adjusted for not assuming equal variances among between-subjects groups. PHQ-9 α = .91 (95 % CI =.88 −.92). SPIN α = .87 (95 % CI =.84 −.90). GAD-7 α = .94 (95 % CI =.92 −.95). PRCA-24 α = .85 (95 % CI =.78 −.89). R-GPTS α = .92 (95 % CI =.89 −.93). All Cronbach's α calculations for the reported measures were bootstrapped based on 1000 samples.

you that others are thinking badly of you? We recorded the responses using a modified scoring range from 0 (not at all) to 4 (extremely). In our sample, the SASCI$_{Modified}$ at baseline showed an α of.85 (95 % CI =.80 −.89, bootstrapped based on 1000 samples).

2.2.5. Secondary outcome measures

2.2.5.1. Performance evaluations. Speech Performance Scale (SPS), is a 17-item instrument that assesses positive (reverse-coded) and negative aspects of speech performance (Rapee & Lim, 1992). Ratings are on a scale ranging from 0 (not at all) to 4 (very much). Higher scores reflect more negative performance evaluations. We included nine out of 17 items (items 1, 3, 4, 6, 7, 12, 15, 16, and 17), with a maximum possible score of 36. The remaining items could not be rated across all conditions (e.g., eye contact, sweating). Participants completed this measure twice: 1. from their point of view (participant - self, 'how you felt you actually performed'), and 2. from the audience's perspective (participant - observer, 'how you think others felt when you performed'). To obtain an external rating of performance, we asked two experimenters to rate the recordings using the same nine-item version of SPS. 25.62 % of the data from one of the experimenter ratings was missing. We estimated the intraclass correlation coefficient (ICC) after dropping the missing cases (listwise deletion). There was good agreement between the assessors (ICC=.73, $F(89) = 3.70$, $p < .001$ CI%95 [.58 −.82]) across 90 participants. Consequently, we report scores from the assessor who rated all performances ($N = 121$). In our sample, the SPS showed high internal consistency across rating sources: participant-self (α =.88, 95 % CI [.85, .92]), participant-other (α =.88, 95 % CI [.83,.92]), and experimenter ratings (α =.92, 95 % CI [.90,.94]; bootstrapped over 1000 samples).

2.2.5.2. Post-event processing. Participants completed the 16 negative rumination items (e.g., I thought about this: - I made a fool of myself), rated on a scale ranging from 0 (never) to 4 (very often) from *The Thoughts Questionnaire (TQ;* Edwards et al., 2003). The TQ showed excellent psychometric properties across subscales (α =.79 -. 94) (Edwards et al., 2003). Higher scores indicate more persistent negative post-event processing. In our sample, the TQ showed an α of.94 (95 % CI =.92 −.95, bootstrapped based on 1000 samples).

2.2.5.3. Observer & field perspective. Participants rated the extent to which they adopted a 'field perspective' or 'observer perspective' during the interaction on a seven-point scale ranging from −3 (entirely looked through my eyes) to + 3 (entirely observed myself from an external point of view).

2.3. Experimental protocol

The videoconferencing session took place on Blackboard Collaborate (https://ca.bbcollab.com/). At the start of the study, participants read the Participant Information Sheet, which explained that 'The videoconferencing task involves you preparing and delivering a short talk on a given topic during an online videoconferencing session…. Your speech will be recorded to be used in the analysis.' The experimenter followed a standardised script and was responsible for managing the session (e.g., introducing the online session and collecting self-reports). Fig. 1 depicts the experimental protocol. The videoconferencing session had several phases that were performed in a fixed order:

Baseline: Before joining the online videoconferencing session, participants provided demographic information before completing baseline measures and current state anxiety ('Baseline, SUDS and SASCI$_{Modified}$). Responses were collected using Qualtrics XM (https://www.qualtrics.com/) (Qualtrics, 2021).

Familiarisation: Participants were automatically directed to the online videoconferencing session. Five dummy audience members were already present either with or without profile images, depending on the experimental group allocation. Once participants joined the online session, the experimenter (first author) welcomed them and introduced the online videoconferencing environment. We restricted video camera access in advance for those assigned to the 'no Speaker video' condition, or we requested participants keep their web camera turned on throughout the online session (Speaker video on condition). Participants rated their self-reported state anxiety levels ('Familiarisation', SUDS and SASCI$_{Modified}$), in which they posted their answers to a private chat. Participants' self-report ratings during the online session were only visible to the moderator, and this was made clear to the participants.

Anticipation: Participants prepared a three-minute talk on a particular topic (i.e., 'The Future of Artificial Intelligence [AI]: The Harms and Benefits'), and were provided with the following prompts: 'dependency on machines', 'restricted work', 'unemployment', 'less room for errors', and 'AI in risky situations'. After one and a half minutes of preparation, participants rated their current state anxiety ('Anticipation', SUDS and SASCI$_{Modified}$). Participants continued preparing their talk for a further 1.5 min during which time 15 more dummy audience members joined the session (20 audience members in total plus the experimenter).

During the preparation phase, a countdown timer was visible, set to three minutes.

Speech: Participants were instructed not to use any other materials or view other monitor screens during their talk. We also recorded the online session, as previous research has shown this further increases social-evaluative anxiety (Dickerson & Kemeny, 2004). At the end of the preparation time, the moderator introduced the participant to the assembled audience as 'today's speaker'. A second experimenter used two dummy audience profiles to post 'Hi everyone; Hello!' in the text chat window. Participants were then verbally instructed to deliver their rehearsed speech over the next three minutes. Before their talk, participants rated their anxiety levels ('Before Talk', SUDS and $SASCI_{Modified}$). During the speech phase, whilst approaching the end of their three-minute talk, the moderator sent two private chat messages (i.e., last 30 s, last ten seconds) to make participants aware of the time they had remaining. After the speech, 15 of the 20 dummy audience members left the online session, with two dummy audience members posted in the chat 'Thank you!' and 'Thanks, bye everyone' before leaving. Participants recorded their state anxiety levels ('After Talk' SUDS and $SASCI_{Modified}$) using the private chat.

Recovery: Before leaving the online session, participants were sent a final Qualtrics URL to complete additional post-activity measures to record their state anxiety, retrospective performance evaluations, perspective taken, and post-event processing ('Recovery', SUDS, and $SASCI_{Modified}$, SPS, observer/field perspective, TQ). Finally, participants recorded their awareness of the audience images and their self-depicting video (not aware at all to totally aware), and rated their familiarity with both videoconferencing (0 = not at all, 10 = extremely), and AI (0 = not at all, 4 = a great deal). Participants were then debriefed.

2.4. Data analytic strategy

Statistical analyses were performed using R Software, version 4.4.0. (R Core Team, 2022). Demographic differences were analysed using one-way Analysis of Variance (ANOVA). We used the package 'afex' (Singmann et al., 2022) to run omnibus models (type III sums of squares; participants/ IDs were treated as random units with repeated measures across Time using an Error(ID/Time) structure). We assessed the change in self-reported anxiety (SUDS and $SASCI_{Modified}$) through Time on Speaker*Audience interaction. To explore the two-way Speaker*Audience interaction effect on performance evaluations, post-event processing, and perspective taking, we conducted separate between-subjects models. We used the package 'emmeans' (Lenth et al., 2018) to carry out simple effect analyses where there was a significant two-way interaction and to carry out post-hoc tests with customised contrasts (consecutive) where there was a significant main effect of Time. Post-hoc tests were adjusted using Bonferroni correction.

We computed Pearson's *r* coefficients to examine the associations between trait measures and peak anxiety from the social interaction task and visualised the results using the 'corrplot' package (Wei & Simko, 2021).

To address the imbalance in gender proportions across conditions, all main analyses were re-run including gender as a covariate. For analyses where there was a lack of sphericity in our repeated-measures, Greenhouse-Geisser corrections were used. Before primary models were performed, Q-Q plots showed slight non-normalities on some primary outcome measures (i.e., $SASCI_{Modified}$). No extreme outliers were detected. In addition, sample size was unequal between the groups. Despite being robust against slight departures from non-normality, unbalanced designs can inflate the Type I error for *F* tests (Rusticus & Lovato, 2014). Therefore, we re-analysed our data on 20 % trimmed means and bootstrapped sample ($N = 1000$) with winsorised variances using the package 'welchADF' (Villacorta, 2017). Analyses are reported when inconsistencies are observed between test results.

2.5. Power analysis

We determined the sample size using the R package 'WebPower' (Zhang et al., 2018) for a three-way interaction effect on subjective anxiety. We estimated a large effect size (Cohen's $f = .40$) based on typical effects reported in in-person/digital social evaluative performance tasks (e.g., $\eta p^2 = 0.17$) (Eagle et al., 2021) and on sample sizes from comparable digital interaction studies (Huneke et al., 2022; Vriends et al., 2017). To have.80 power at $p < .05$, the recommended sample size was 120.

3. Results

3.1. Group characteristics

One-way ANOVAs, using Welch's *F* as the test statistic, confirmed that the groups did not differ in terms of gender, age, and self-report baseline measures including social anxiety, communication apprehension, generalized anxiety, depression and paranoia (Table 1). Participants across four groups reported moderate levels of videoconferencing experience. Mean SPIN scores ranged from 28.55 ± 9.28–33.88 ± 12.04 across four groups, indicating mild to moderate social anxiety symptoms for our sample.

3.2. Main analyses: state anxiety and state social anxiety

Descriptive statistics are presented in Fig. 2 (SUDS – top panels, $SASCI_{Modified}$ – lower panels). Table 2 lists the interaction and main effects as well as follow-up tests on state anxiety measures of SUDS and $SASCI_{Modified}$. All observed means and standard deviations for outcome measures are presented in Table S1 (appendix).

Separate 2 (Speaker camera: on, off) x 2 (Audience camera/images: on, off) x 6 (Time: baseline, familiarisation, anticipation, before speech, after speech, recovery) models were run with SUDS and $SASCI_{Modified}$ as dependent variables. Consistent with predictions, main effects of Time (*ps* < .001) were characterised by significant increases in state anxiety and state social anxiety from baseline, that peaked just before delivering the speech. State anxiety (SUDS) and state social anxiety ($SASCI_{Modified}$) decreased after the talk (*ps* < .001), although state social anxiety ($SASCI_{Modified}$) increased again during the recovery period ($p = .003$).

A main effect of speaker camera provided evidence that state anxiety was higher when participants had their camera on. However, neither anxiety (overall during the session) nor changes in anxiety (over time) were affected by audience camera/images, nor by interactions between speaker and audience camera (*Fs* < 1.65, Table 2).

Our data revealed non-normal distributions of residuals on the $SASCI_{Modified}$ measure. Consequently, we re-ran the analysis using Welch-James statistics (Villacorta, 2017). This revealed a main effect of Speaker Camera (*WJ* $F(1, 378.2) = 9.61$, $p = .002$) but also revealed an interaction between Speaker Camera and Audience Camera (*WJ* $F(1, 378.2) = 5.65$, $p = .017$; Fig. 3). Follow-up simple main effects analyses revealed that social anxiety was lower when participants and audience together had their camera/images off, particularly when compared to the elevated levels of social anxiety that were experienced when participants had their cameras on, but the audience did not ($F(1, 117) = 4.19$, $p = .042$). When the audience camera was on, speaker camera visibility did not significantly influence anxiety ($F(1, 117) = 0.12$, $p = .726$).

Gender was a significant covariate for the anxiety measures (SUDS and $SASCI_{Modified}$), however, including gender did not alter the overall pattern of interaction effects. For SUDS, the previously marginal main effect of speaker camera shifted from $p = .045$ to $p = .058$ when gender was added to the model.

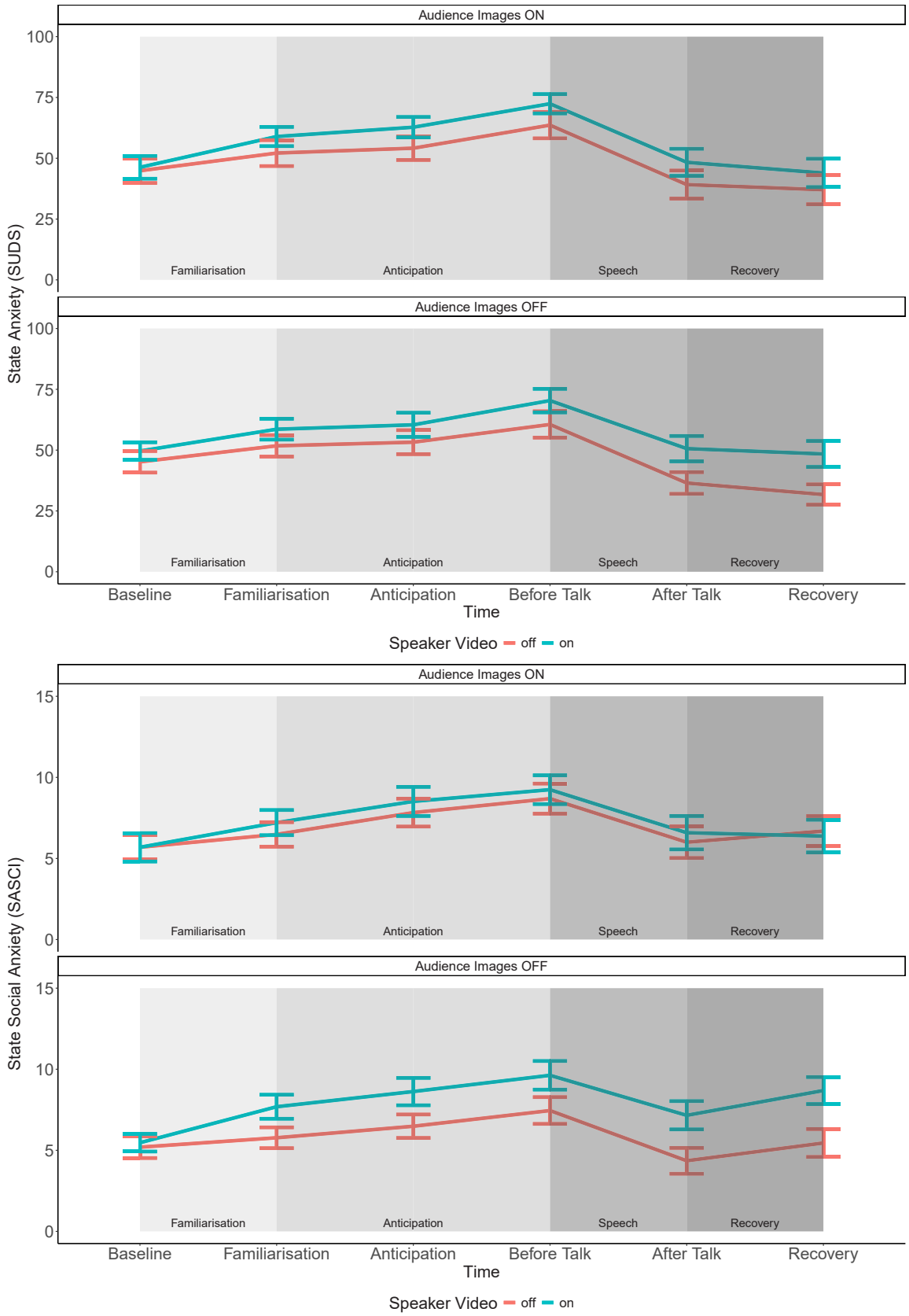

Fig. 2. *Three-way Speaker*Audience*Time Interaction Plots for State Anxiety and State Social Anxiety.*

Table 2
Test Statistics of Omnibus and Follow-up Tests on the Self-Reported Anxiety Throughout the Online Session.

	State anxiety / SUDS				State Social Anxiety / $SASCI_{Modified}$			
	(df), *F*		*p*	ηp^2	(df), *F*		*p*	ηp^2
Speaker (Camera)	(1, 117), 4.10		**.045**	.034	(1117), 2.79		.097	.023
Audience (Image)	(1, 117), 0.02		.894	< .001	(1, 117), 0.12		.732	.001
Time	(2.56, 300.05), 48.80		**< .001**	.294	(3.04, 355.91), 30.57		**< .001**	.207
Audience X Time	(2.56, 300.05), 0.27		.816	.002	(3.04, 355.91), 0.97		.408	.008
Speaker X Time	(2.56, 300.05), 1.37		.256	.012	(3.04, 355.91), 1.65		.177	.014
Audience X Speaker	(1, 117), 0.12		.727	.001	(1, 117), 1.36		.247	.011
Audience X Speaker X Time	(2.56, 300.05), 0.51		.648	.004	(3.04, 355.91), 1.63		.181	.014
Change in Time	*t*(116)	Lower Upper 95 % CI	*p*	*d*	*t*(116)	Lower Upper 95 % CI	*p*	*d*
Baseline to Familiarisation	6.28	[5.18 12.56]	**< .001**	0.36	4.06	[0.45, 2.10]	**< .001**	0.32
Familiarisation to Anticipation	1.68	[-1.28 5.84]	.478	0.08	5.73	[0.58, 1.57]	**< .001**	0.24
Anticipation to Before Speech	6.47	[5.42 12.77]	**< .001**	0.40	4.92	[0.41, 1.36]	**< .001**	0.19
Before Speech to After Speech	-9.98	[-29.14–17.03]	**< .001**	0.81	-8.89	[-3.54, −1.93]	**< .001**	0.54
After Speech to Recovery	-3.46	[-5.93–0.82]	**.003**	0.11	4.49	[0.32, 1.23]	**< .001**	0.15

Note. SUDS (Subjective Units of Distress), SASCI (Social Anxiety Session Change Index). See Fig. 1 for a summary of the protocol and time points. Effect size of partial eta squared (ηp^2) is reported for main effects and interactions, and d $(M_2 - M_1)/SD_{pooled}$ is reported for pairwise comparisons.

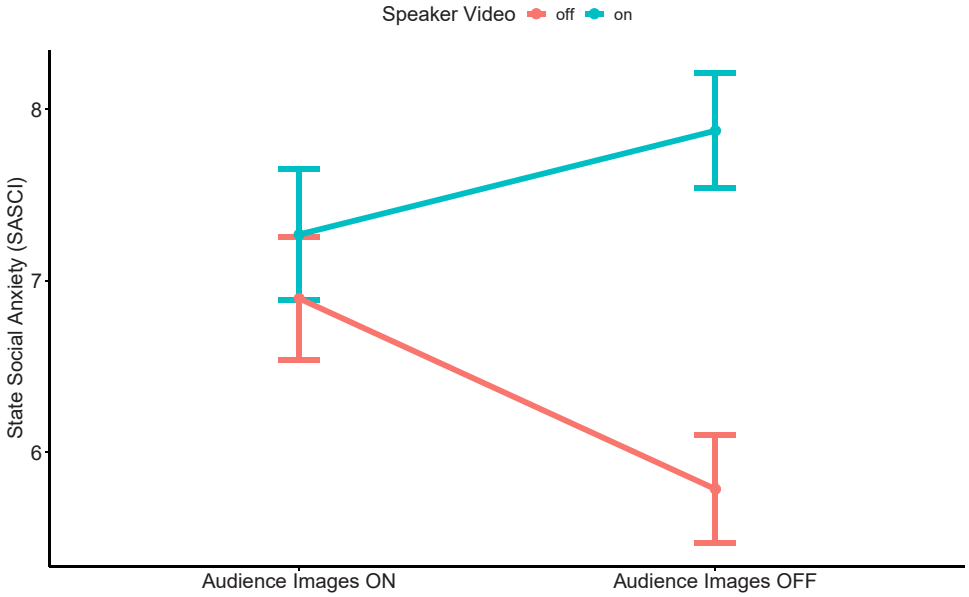

Fig. 3. *The Interaction Effect of Audience*Speaker for State Social Anxiety. Note.* Higher scores denote higher levels of state social anxiety. Error bars represent standard error (SE).

3.3. Performance evaluations from self perspective, other perspective and experimenter ratings

Participants rated their own performance (self) most negatively when they had their camera on but presented to an audience who had their camera/images off. In contrast participants rated their performance most positively when both they and the audience had their cameras/images off [Speaker Camera x Audience Camera interaction, $F(1, 117) = 5.39$, $p = .022$, $\eta p^2 = .044$ - Fig. 4A]. A similar pattern was observed when participants rated their performance from the perspective of the audience [Speaker camera x Audience Camera interaction, $F(1, 117) = 6.25$, $p = .014$, $\eta p^2 = .051$ - Fig. 4B]. However, the independent experimenter rater did not rate performance differently across camera conditions, F's$(1, 117) < 2.42$ p's $> .123$, $\eta p^2 < .020$ - Fig. 4C.

3.4. Discrepancy between 'self' and 'experimenter' ratings

To examine whether participants rated their performance more negatively than the experimenter, we calculated 'difference scores' for participants in each camera condition. One sample *t*-tests (vs. 0) suggested that participants in all four camera conditions rated their performance more negatively than the experimenter (t's > 3.457, p's $< .002$). However, the omnibus model showed that this self vs. experimenter bias was more negative in participants who presented with their self-video on, $F(1, 117) = 5.23$, $p = .024$, $\eta p^2 = .043$ but was not moderated by presence/absence of audience images, $F(1, 117) = 2.33$, $p = .129$, $\eta p^2 = .020$.

3.5. Post-event processing

Participants post-event negative ruminations were greater if they presented with their camera on, to audience members with their camera off, and lowest when both they and audience had cameras off [Speaker Camera x Audience Camera interaction, $F(1, 117) = 4.74$, $p = .032$, $\eta p^2 = .039$ – Fig. 4D].

3.6. Observer versus field perspective

One-sample *t*-tests (vs. 0 indicating no bias) showed that in three out of four camera conditions, participants adopted a strong field

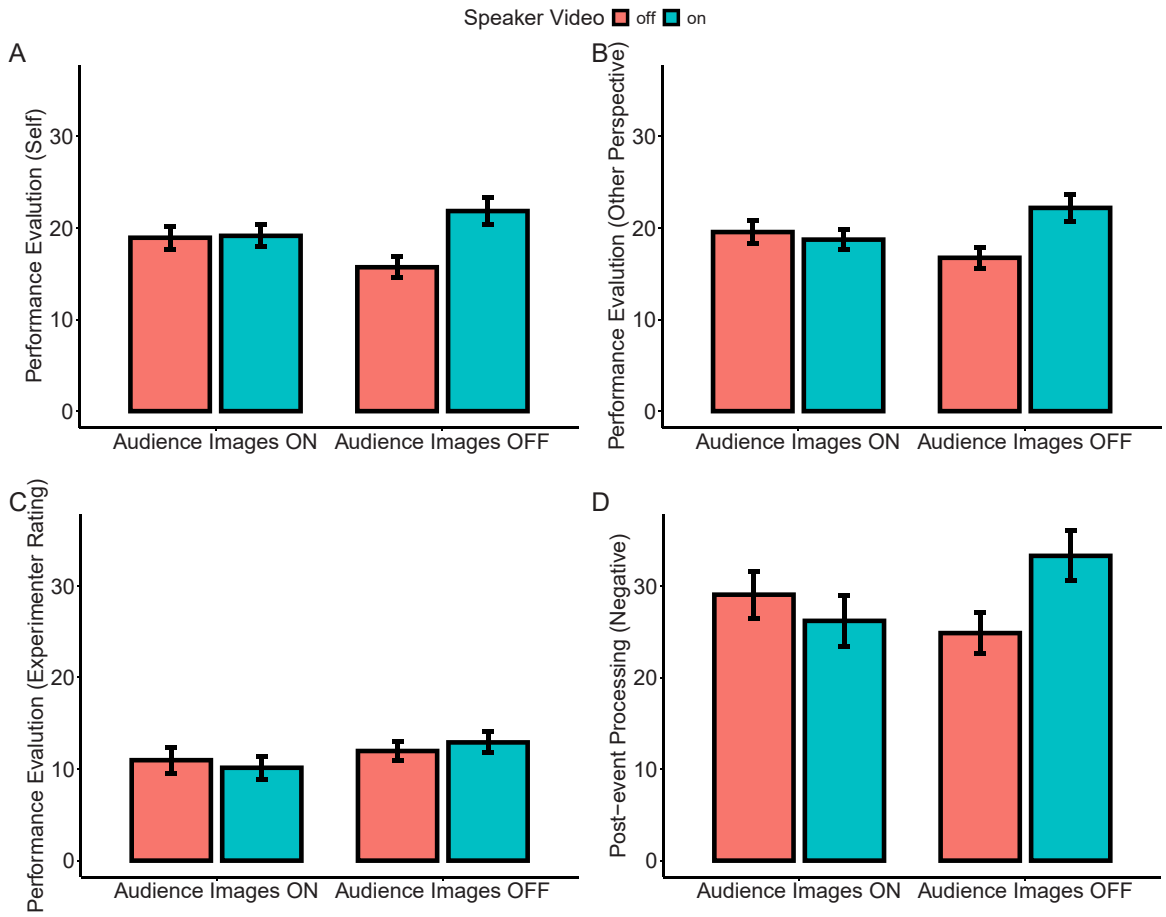

Fig. 4. *Performance Evaluations and Post-event Processing from 'Self' and 'Other' Perspectives, and Experimenter Ratings of Performance. Note.* Higher scores denote worse performance evaluations and more negative post-event processing. Error bars represent + /- 1 Standard Error (SE).

perspective during the social interaction (i.e., viewed the interaction through their own eyes (t's > 1.93, p's < .064, 95 % CI range: [-1.63, 0.05], Fig. 5A). In contrast, participants who presented with their camera on, to an audience who had their camera off, reported neither adopting a strong observer nor field perspective, ($t(31) = 0.63$, $p = .536$, 95 % CI [-0.80, 0.42], Fig. 5A).

3.7. Awareness of self videos and audience

Participants did not report greater audience awareness when audience images were visible, $F(1, 117) = 2.43$, $p = .122$, $\eta p^2 = .020$, irrespective of whether their own camera was presented or not, $F(1, 117) = 0.86$, $p = .357$, $\eta p^2 = .007$ (Fig. 5B). In contrast, participants felt greater awareness of their self-video when their camera was turned on vs. off, $F(1, 117) = 3.94$, $p = .049$, $\eta p^2 = .033$ (Fig. 5C). Audience profile images did not influence this effect, $F(1, 117) = 0.42$, $p = .517$, $\eta p^2 = .004$.

3.8. Correlations between trait measures and peak anxiety

Across our full sample, the level of peak anxiety experienced during the interaction positively correlated with symptoms of social phobia (SPIN), generalized anxiety (GAD-7), depression (PHQ-9) but not paranoia (Figure S1 panel A, appendix). Levels of negative self-evaluation, post-event processing and observer perspective-taking were correlated with each other and associated with social anxiety symptoms (SPIN), communication apprehension (PRCA-24) and to lesser extent with generalized anxiety (GAD-7). We were interested in whether self/audience condition moderated the relationship between social anxiety (SPIN) and peak anxiety. We observed positive associations between social phobia and peak anxiety only when participants presented with their camera on (Figure S1 panels B,C,D,E, appendix).

4. Discussion

We investigated the impact of online videoconferencing on individuals with high social anxiety during a live public speaking task. Specifically, we manipulated the presence of self-view video feeds and audience images to explore their influence on anxiety, self-image, performance evaluations and post-event processing.

The online videoconferencing task effectively induced anxiety in our sample of individuals with elevated social anxiety, consistent with prior research in both in-person and digital settings (Hawn et al., 2015; Kirschbaum et al., 1993; Shiban et al., 2016). Anxiety peaked prior to delivering the online speech, similar to anxiety profiles observed in previous social interaction studies online (Eagle et al., 2021; Huneke et al., 2022). Measures of state social anxiety similarly peaked before the task, decreased after the speech, but increased again post-speech during the recovery period – suggesting the task can sustain social evaluative (rather than general) concerns, before, during and after social interaction; and highlighting the value of disorder specific scales to measure symptoms in acute challenge studies. State social anxiety was elevated in participants who had their camera on post-speech, and peak social anxiety was predicted by levels of pre-existing social anxiety (SPIN) in this group. Anxiety was unaffected by the presence or absence of the audience image alone.

In contrast, measures of negative post-event processing were modulated by the interaction between audience image and self-image.

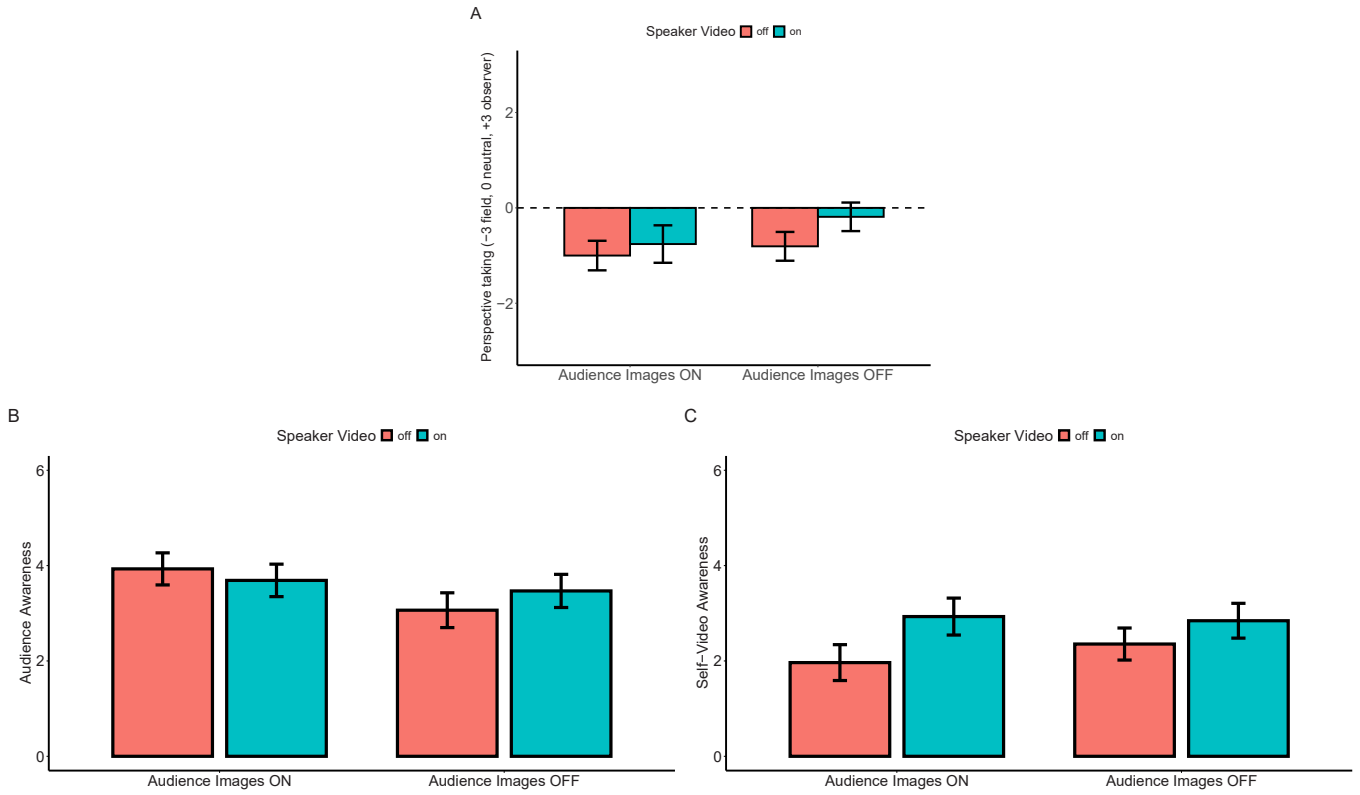

Fig. 5. *Perspective Taken and Awareness for Speaker*Audience Interaction. Note.* For panel A, dashed lines denote 0 (no bias). Error bars represent + /- 1 Standard Error (SE).

Specifically, we observed greater negative self-performance ratings, and more negative ruminations when participants presented with their camera on to audience members who had their camera off. These participants reported neither adopting a clear observer nor field perspective, in contrast to strong field perspectives observed in the other three groups. Correlations revealed strong associations between field perspective taking and less negative post-event processing biases. Consequently, together, these findings suggest that conditions that encourage a field perspective may reduce maladaptive post-event cognitions in online contexts. The absence of a strong observer perspective in our study differs from previous findings in person interactions (e.g., (George & Stopa, 2008; Wells et al., 1998; Wells & Papageorgiou, 1999)). One possible reason could be the short time frame between the task and measurement; Coles et al. (2002) found that observer perspective increases over time. Therefore, future studies may include repeat assessments to clarify how perspectives change and interact with other cognitive biases online.

In our study, participants reported similar levels of audience awareness regardless of whether audience images were hidden/visible and these effects were not modulated by self-camera status. We are not aware of other studies that have demonstrated this effect. In contrast, participants reported greater awareness of their self-video when their camera was on, suggesting that self-video may increase self-awareness and hold particular relevance for understanding social anxiety in digital interactions. Future research may examine observer perspective taking and self-image in an additional control condition in which the participant cannot see their video image that is presented to the audience. This condition reflects interactions in real life (not online) when our audience sees us, but we do not see ourselves. In our study, we did not ask participants to monitor their video image, and as is typical in online displays the self-image was small compared to the audience array. However, our use of self-report measures limited our ability to assess attentional shifts, and future studies could use eye-tracking methods to examine overt shifts in attention between self-video, audience screen and off-screen and to clarify how internal and external focus interact during online social evaluations. While our sample was screened for high social anxiety using SPIN, results may differ for clinically diagnosed individuals. Prior research (Vriends et al., 2017) suggests that online feedback mechanisms might influence subclinical and clinical individuals differently, with clinical individuals showing more consistent self-focus across social scenarios.

We did not observe performance deficits as rated by an experimenter - participants exhibited more negative self-evaluations when audience images were absent and the self-view video was present. This may relate to the heightened intolerance of uncertainty observed in socially anxious individuals (Boelen & Reijntjes, 2009; Carleton et al., 2010), where the ambiguity caused by invisible audiences could heighten self-focus and lead to distorted self-assessments. The illusion of being watched without visible cues might amplify negative self-appraisals, especially in a performance setting like a speech task, where subjective interpretation plays a stronger role than interpersonal dynamics. Given subjective evaluations were not mirrored in objective ratings, our findings suggest that socially anxious individuals may misinterpret their performance rather than exhibit actual deficits (Brozovich & Heimberg, 2011; Perini et al., 2006) particularly in speech tasks (in our study) compared to interpersonal conversation (Voncken & Bögels, 2008).

Negative interpretative bias of ambiguous social information is common in social anxiety (for meta-analysis see Chen, Short, et al., 2020). Survey studies reveal associations between social anxiety and interpretative bias in offline and online social media environments (Miers et al., 2020), though interpretative biases in live online interactions have not been examined in social anxiety. Our audience comprised a live researcher and array of 'typical' profile pictures (in camera on conditions). We were mindful that interpretative biases may impact results so used the same female researcher, who followed a standard script, in all sessions. However, we did not measure the extent

to which participants evaluated these individuals as positive or negative, or attributed personality characteristics to individuals based on the profile pictures. We do not yet have validated online dynamic stimuli for research in this area - unlike other tools for experimental psychopathology research (e.g., static facial expressions of emotion or International Affective Picture images [IAPS]; Lang et al., 2008), and pre-recorded and rated dynamic audience stimulus sets would improve the control and cultural inclusivity of research in this area.

What are the possible clinical implications of our findings? Cognitive behavioural therapy (CBT) for social anxiety includes psychoeducation, identifying negative thoughts, cognitive restructuring, exposure to feared situations, behavioural experiments and social skills training to reduce avoidance, challenge distorted beliefs, and build confidence in social interactions. Our findings suggest online interaction tasks can increase anxiety and negative performance evaluations in individuals who experience social anxiety and can be considered for behavioural exposure exercises in therapy. The camera manipulations provide opportunities to familiarise anxious individuals with cognitive-behavioural theoretical models that guide CBT sessions, and component processes (self-image, perspective taking and safety behaviours) that can be targeted in graded exposure and natural experiments to correct maladaptive cognitions and behaviours. The task may support exercises that are completed 'online' and afterwards 'offline' through recorded watch-back to target rising anxiety in-situ and also post-event processing biases that may elicit anxiety between feared social interactions. For individuals who experience anxiety specifically in online interactions, our findings highlight conditions that may graduate anxiety during behavioural exposure (self camera-off/audience camera-off through to self-camera on/audience camera-off). Finally, online digital interactions may more easily embed computerised cognitive bias modification training interventions that show some promise in social anxiety (Biagianti et al., 2020) - for example interpretative bias training for different sources of ambiguity e.g., when audience camera is on and off or when self-video is attended to and evaluated. Interestingly, no participants withdrew from our online speech task, suggesting online provocation tasks may provide an acceptable component of CBT interventions, though acceptability and tolerability studies that compare internet-based and face to face CBT are required in this area (Andersson et al., 2014).

We note the following limitations. First, we revealed similar self-awareness across groups, particularly in relation to audience visibility. This could possibly be due to retrospective reporting or the general salience of being observed online being sufficient to trigger evaluative concerns (Andrews et al., 2007). Secondly, our sample lacked diagnostic clinical verification, and we did not control for comorbid conditions or examine a low-anxiety control group. Additionally, our randomisation did not balance gender across groups - audience camera-on conditions included a higher proportion of female participants. Our covariate-adjusted analyses modelled the influence of gender but our study was not powered to examine effects within genders. Furthermore, our study was powered to detect large effects based on typical effects reported in in-person and digital social evaluative performance tasks (e.g., Eagle et al., 2021); however, smaller effects may not have been reliably detected. Future research with larger samples would allow for greater sensitivity to medium and small effects. Lastly, the variability inherent in online setups (e.g., internet quality) introduces uncontrolled variables despite efforts to standardise conditions.

Despite these limitations, this study successfully adapted a widely used in-person speaking paradigm to investigate cognitive mechanisms of social anxiety in online interactions. Our findings contribute to a growing literature on digital communication's psychological effects, which is increasingly relevant given the expansion of online platforms in education, employment, and healthcare. Future research should integrate physiological and attentional measures (e.g., eye-tracking), and consider varying interface layouts (e.g., feedback symmetry, group chat) to assess their effect on self-focus and social threat processing. Pre-recorded videos of audiences with varying emotional expressions could be used to better control real-time feedback.

In conclusion, our study provides evidence that online videoconferencing can reliably evoke anxiety in individuals with high social anxiety and reveals that camera features such as self-view and audience presence can influence cognitive distortions post-performance. Importantly, audience visibility appears to reduce negative post-event processing and performance self-evaluation biases, suggesting that small adjustments to online platform settings may alleviate some adverse effects of virtual communication for socially anxious individuals.

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CRediT authorship contribution statement

Neslihan Özhan: Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Matthew Garner:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Erich W Graf:** Writing – review & editing, Supervision, Methodology, Conceptualization.

Declaration of Generative AI and AI-assisted technologies in the writing process

None.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.janxdis.2026.103111.

Data availability

Data will be made available on request

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