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ORIGINAL ARTICLE

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Psychophysiological responses to eye contact in a live interaction and in video call

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Abstract

Another person's gaze directed to oneself elicits autonomic arousal and facial reactions indicating positive affect in its observer. These effects have only been found to occur with mutual, live eye contact and not in response to direct gaze pictures or when the observer believes that the live person cannot see them. The question remains whether the physical presence of the other person is necessary for these effects. We measured psychophysiological responses to another person's direct versus averted gaze in three conditions: live interaction, bidirectional video call, and watching a mere video. Autonomic arousal was measured with skin conductance responses and facial reactions with facial electromyography. In the live and video call conditions, but not in the mere video condition, direct gaze increased autonomic arousal in comparison to averted gaze. In all three conditions, however, direct gaze elicited positive affective facial reactions. Therefore, an experience of being seen is essential for the autonomic reactions but not for the facial responses that are elicited by another person's direct gaze. Most importantly, the results suggest that the physical presence or proximity of the other person is not necessary for these psychophysiological responses to eye contact.

KEYWORDS

autonomic arousal, direct gaze, EMG, eye contact, skin conductance, video call

1 | INTRODUCTION

Eye contact has an important role in social interaction. Another person's gaze direction indicates the direction of their attention (Itier & Batty, 2009), and, when it is directed toward oneself, it is usually perceived as a positive social signal, such as a sign of liking or communicative intent (for a review, see Kleinke, 1986). People who make eye contact are perceived as more pleasant, competent, and attractive than those who avoid direct gaze. Eye contact has also been found to elicit affect-related psychophysiological responses in the perceiver (for a review, see Hietanen, 2018). Interestingly, however, it is unclear what gives rise to these effects. Some previous accounts have focused on the effects elicited by the mere sensory input, that is, the perception of a person's eyes directed toward the self (e.g., Senju & Johnson, 2009), whereas others have stressed the importance of a psychological mechanism, an experience of being seen by another person (e.g., Conty, George, & Hietanen, 2016; Myllyneva & Hietanen, 2015; Teufel, Fletcher, & Davis, 2010).

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In accordance with the latter view, many of the psychophysiological responses to eye contact are only elicited by the gaze of a live person. Studies that have contrasted the perception of a live person with that of a picture or a video have found that the effect of eye contact on autonomic nervous system seems to be limited to a live person's gaze (Hietanen, Leppänen, Peltola, Linna-aho, & Ruuhiala, 2008; Pönkänen, Peltola, & Hietanen, 2011; Prinsen & Alaerts, 2019). In these studies, another person's direct gaze in comparison to averted gaze elicited greater skin conductance responses (SCR) indicating greater autonomic arousal. This effect occurred only when participants were facing a real person whereas, when they were looking at a mere picture or video, the perceived gaze direction did not influence autonomic arousal. Accordingly, studies that have used only pictorial stimuli have often found no difference in SCRs between the perception of direct and averted gaze (Joseph, Ehrman, McNally, & Keehn, 2008; Leavitt & Donovan, 1979; Lyyra, Myllyneva, & Hietanen, 2018; Wieser, Pauli, Alpers, & Mühlberger, 2009), though some studies have reported a greater arousal response to direct gaze in certain study conditions or participant groups also when showing pictures of faces (Conty et al., 2010; Kylliäinen & Hietanen, 2006; Soussignan et al., 2013). Similarly, studies that have assessed arousal by measuring pupillary responses have not found a consistent response to pictorial presentations of direct versus averted gaze (Kampe, Frith, & Frith, 2003; Porter, Hood, Troscianko, & Macrae, 2006). In facial electromyography (EMG) studies, responses associated with positive emotion—activation of the *zygomaticus major* muscle and relaxation of the *corrugator supercilii* muscle—have been observed in response to live, direct gaze stimuli bearing a neutral expression (Hietanen et al., 2018). Studies using pictorial stimuli, however, have not found a similar effect (Mojzisch et al., 2006; Rychlowska, Zinner, Musca, & Niedenthal, 2012; Schrammel, Pannasch, Graupner, Mojzisch, & Velichkovsky, 2009; Soussignan et al., 2013). Moreover, studies comparing brain responses to different presentation modes of direct and averted gaze stimuli have found certain effects only in response to a live person's direct gaze. Two studies that investigated the asymmetrical frontal brain activity with electroencephalographic (EEG) recordings found relatively more left-sided brain activity indicating increased approach motivation in response to live direct versus averted gaze (Hietanen et al., 2008; Pönkänen, Peltola, et al., 2011). This effect was also observed only when facing a real person and not while looking at a mere picture. Similarly, studies on event-related potentials (ERP) and functional magnetic resonance imaging (fMRI) responses to live and pictorial presentations of direct and averted gaze stimuli have found effects associated with social and affective cognition (enhanced N170 and EPN amplitudes and anterior medial prefrontal cortex activity) in response to a live person's direct versus averted gaze, but not to pictures of direct versus averted gaze (Cavallo et al., 2015; Pönkänen, Alhoniemi, Leppänen, & Hietanen, 2011). Taken together, these studies strongly imply that an experience of being seen by another person may influence the effects that direct gaze has on its observer.

The effect of being seen by another person was directly investigated by Myllyneva and Hietanen (2015). They manipulated the belief of being seen by presenting participants with a view of another live person's direct and averted gaze either with or without an alleged one-way mirror in between them. Autonomic arousal responses (SCRs) as well as psychophysiological orienting responses (heart rate deceleration and frontal P3 ERPs) were enhanced to direct gaze only if participants believed that the other person could see them. Corroborating this finding, a recent study showed that prolonged eye contact elevated participants' skin conductance level only when it was bidirectional, that is, when a person was both seeing and being seen by another person (Jarick & Bencic, 2019). These results provide considerable evidence that a bidirectional view between the two people is an essential prerequisite for many of the affective and cognitive effects of eye contact.

Importantly, however, all of the aforementioned studies employed study designs where the other person was present in the same room. This warrants the question of whether the physical presence of the other person is also required for the effects. An fMRI study by Redcay and colleagues (2010) suggests that social interaction, and not the physical presence of the other person, is the crucial variable for the elicitation of at least some of the neurocognitive effects caused by the perception of direct gaze. In their study, participants either engaged in an interaction with an experimenter over a video call or watched a recording of the same interaction. During the video call, but not while watching the video, enhanced activation was observed in brain areas related to social cognition (right temporoparietal junction and right superior temporal sulcus) and reward processing (ventral striatum and right amygdala). However, because these conditions were not compared to a live interaction with another person present in the same physical space, it is unclear whether the effects of a video call are equal to those elicited by a natural, live encounter with the other person. To our knowledge, no previous study has directly investigated what role the other person's physical presence plays on the effects that eye contact evokes.

In the present study, we investigated whether the physical presence of the other person is necessary for the psychophysiological responses to eye contact. For this purpose, the effects of live eye contact, eye contact over a bidirectional video call, and watching a mere video of the other person were compared. In each of the three conditions, responses to direct gaze were compared to those elicited by gaze averted to the side. We measured participants' autonomic arousal with skin conductance and affective facial responses with facial EMG.

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If the physical presence of the other person is necessary for the psychophysiological effects, only live eye contact, and not eye contact over a video call, will elicit greater autonomic arousal responses and facial muscle responses associated with positive affect than averted gaze within the same condition. If, however, the physical presence of the other person is not required and being seen by the other person is the only essential prerequisite of the two, these responses will be elicited by both live eye contact and eye contact over a video call. In either case the perceived gaze direction is not expected to have an influence on these responses when watching a mere video of the other person. We also measured participants' subjective feelings of arousal and valence to investigate whether awareness of being observed or the other person's presence affect these evaluations.

2 | METHOD

2.1 | Participants

The participants were 32 adults (16 women, 16 men, M_{age} = 27.8 years, SD_{age} = 5.3, age range = 20–42 years) recruited from email lists of University of Tampere and a local Facebook group. Sensitivity analysis ($1–\beta = .80, \alpha = .05, df_n = 2, df_{dn} = 62$, estimated correlation = .5, ε = 1) with G*Power (Faul, Erdfelder, Lang, & Buchner, 2007) indicated that, with this sample size, a 2 × 3 ANOVA can detect medium interactions ($\eta^2 = .05$, effect size specification as in GPower 3.0) between factors. This is the crucial statistical test for determining whether responses to the gaze directions differ between conditions. The participants were all native speakers of Finnish with no reported history of neurological or psychiatric disorders. They all had normal or corrected-to-normal vision. Participants were rewarded with a movie ticket or course credit. The study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) and with a protocol reviewed by the Ethics Committee of the Tampere region. All participants gave their written informed consent.

2.2 | Stimuli

The experiment consisted of three conditions: a live interaction, a video call on a computer, and watching a mere video on a computer screen. In all conditions, the stimulus was the face of a model person of the same sex as the participant presented against a black background. Two research assistants (one of each sex) served as models. The models were both native Finnish speakers. The female model was 26 years old having Nicaraguan and Finnish ancestry, and the male model was 22 years old and of Zambian and Finnish ancestry. The models had a neutral expression and they maintained their faces as motionless as possible. Depending on the trial, they directed their gaze either straight ahead or approximately 30° to the left or to the right. There were no other experimental conditions and no other stimuli were presented to the participants. In all conditions, the stimuli (a live face or the same face appearing on a computer screen) were presented through a voltage-sensitive, liquid-crystal shutter window (NSG UMU Products Co., Ltd.) measuring 21.5 cm × 38 cm. The shutter window was attached to a black panel that was placed on a black table. There was also a computer screen and a keyboard on participants' side of the table for responding to questionnaires. Participants were seated at a distance of 80 cm from the shutter window. The state of the shutter window (transparent or opaque) was controlled with E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, PA) on a desktop computer. The shutter window switched between opaque and transparent states in 3 milliseconds. For an illustration of participants' view in live and video call conditions, see Figure 1.

The stimulus in the live condition was the face of the model person on the other side of the shutter window at a distance of 60 cm from it. In the video call and video conditions, the stimuli were presented on a 19-inch computer screen placed at a distance of 28 cm behind the shutter window. During these conditions, the model person was in another room sitting in front of a computer screen and a web camera that transmitted his or her image in real time to the participants'

FIGURE 1 Participants' view of the model person's direct gaze in the live (left) and video call (right) conditions. In the mere video condition, the view on the screen was identical to that in the video call condition. The computer screen (for questionnaires) is visible in the forefront

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screen. See Figure 2 for an illustration of the setup in each condition. In all conditions, participant's view of the size and location of the stimuli was controlled. The width of the face stimulus in participant's view was approximately 7°. In the beginning of each condition, the model person's seat was adjusted so that his or her face was directly in front of the participant and at the same height as the participant's face. In the video call and video conditions, an impression of eye contact was achieved by placing the web camera and computer screen on the model person's side far enough from the model person so that it appeared as if he or she was looking directly at the camera even though, during seat adjustment, the model person was looking at the screen beneath it. During stimulus presentations, the model person was always looking either directly in the eye region of the participant (live condition) or directly into the camera (video call and video conditions). Great care was taken to ensure that the stimuli were visually comparable in the three conditions and that the direct gaze looked direct in all conditions. In the video call condition, a web camera was on top of the computer screen so that the model person was able to see the participant, which the participant was aware of. In the beginning of the mere video condition, the web camera was on top of the screen for seat adjustment, after which it was removed, and the disconnected cable was shown to the participant. In these two conditions, audio interaction between the participant and the model person was enabled with the web camera microphone, and thus, audio interaction was only possible when the web camera was connected. Importantly, after seat adjustment, no audio interaction took place in any conditions. The shutter window was opaque at all times except during seat adjustment and stimulus presentations.

2.3 | Procedure

After arriving at the laboratory, the participant was informed that in the experiment physiological measurements and questionnaire data would be collected during a simple interaction situation. After this, the experimenter obtained the participant's informed consent. The model person was already present in the laboratory, but he or she did not give any instructions. The measurement sensors were then attached to the participant's left hand and face. To conceal the purpose of the facial sensors, the experimenter told that the sensors were used to measure skin temperature. EEG was also measured to investigate research questions not related to this article.

The experiment consisted of three conditions that were presented in a counterbalanced order. In the live condition, the stimulus was a live model person's face on the other side of the shutter window. In the video call condition, a computer screen with a similar view of the model person's face was on the other side of the shutter window. A web camera was on top of the screen to enable a bidirectional view between the two. The video condition was otherwise similar to the video call condition, except that there was no web camera, and thus, the participants merely watched the face stimuli without being themselves seen by the model person. Each condition began with the model person adjusting his or her seat and confirming that the participant also perceived their eyes to be on the same level.

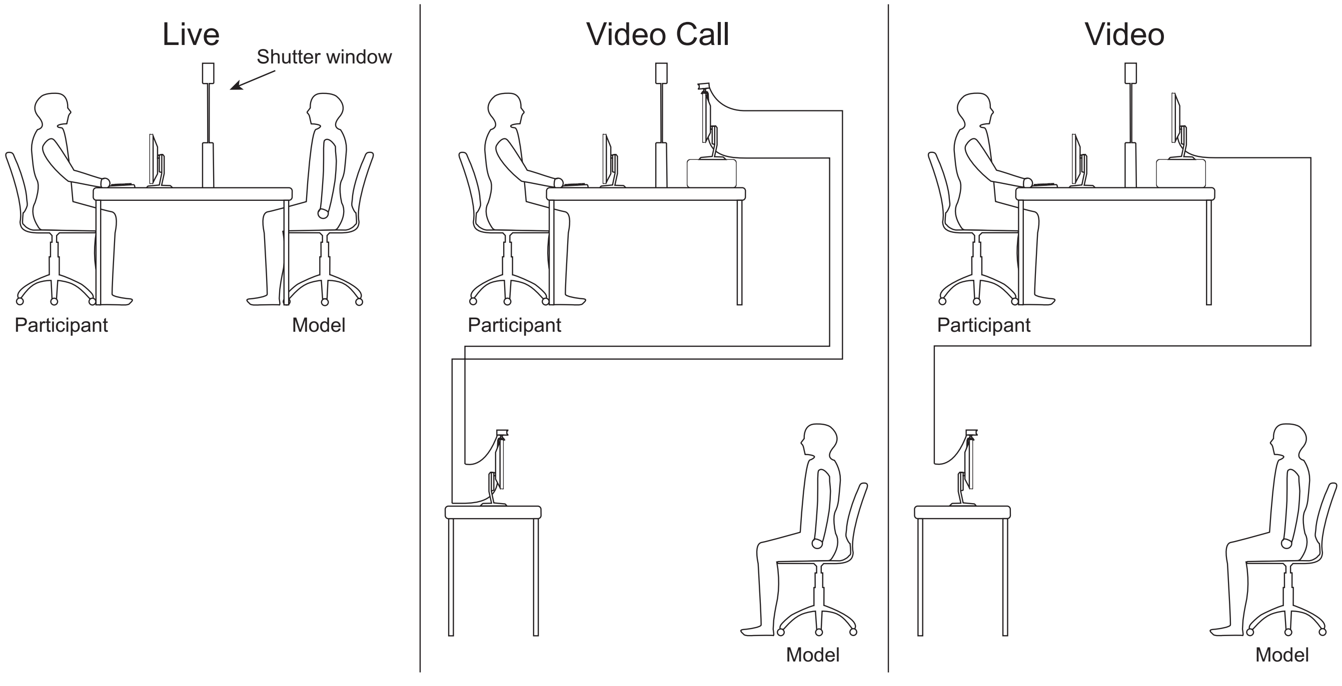

FIGURE 2 An illustration of the experimental setup in the three conditions. In the video call and video conditions, the model person was in another room and his or her image was portrayed in real time with a zoomed-in web camera. The distances are not in exact scale

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Each condition began with 16 trials of stimulus presentation for 5 s at a time during which the physiological responses were measured. On eight trials, the model person directed his or her gaze straight ahead (direct gaze), and on eight trials, to either side (averted gaze, four trials to each side). The trials were presented in a pseudorandomized order with no more than two consecutive trials with the same gaze direction. After each trial, there was an interstimulus interval (ISI) of at least 14.5 s during which the shutter window was opaque. After the experimenter had confirmed that the participant's skin conductance had returned to the prestimulus level, the next trial was started.

In each condition, physiological measurements were followed by questionnaires. Participants completed two questionnaire tasks regarding self-referential processing and self-awareness. Together these two tasks consisted of 13 trials per condition, each with a 5-s presentation of direct gaze stimulus. For conciseness and because these measures were not directly related to the research question of the present study, they are reported in Appendix A in the online Supporting Information.

Subjective valence and arousal evaluations were assessed with the Self-Assessment Manikin (Bradley & Lang, 1994) in response to direct and averted gaze in all conditions. Participants first read instructions on the computer screen telling them that soon they will see the presentations again and, during each presentation, the task is to evaluate their level of arousal and valence. The instructions informed them about the meaning of arousal and valence and about the used scale. They were presented with either direct or averted gaze for 5 s, and then, asked to evaluate their subjective feelings on the two dimensions on a 9-point scale (1 = calm/unpleasant, 9 = arousing/pleasant). They were then similarly presented with the other gaze direction. The order of the gaze directions was pseudorandomized.

After the three conditions, the measurement sensors were removed. Participants were then administered a questionnaire unrelated to the present study, debriefed, thanked, and given the participation rewards. No other data were collected in the experiment.

2.4 | Acquisition and analysis of physiological data

2.4.1 | Skin conductance

Skin conductance was measured with two electrodes (Ag/AgCl) coated with isotonic paste and attached to the palmar surface of the medial phalanges of the index and middle fingers on the participant's left hand. SCRs and EMG were recorded using a BrainVision QuickAmp amplifier and BrainVision Recorder software (Brain Products GmbH, Munich, Germany) at a sampling rate of 1,000 Hz.

Offline, the SCR data were resampled to 100 Hz and filtered with a 10 Hz low-pass filter. Response was defined as the maximum, continuous increase in amplitude within a time frame of 0.9–6.5 s after stimulus onset. The response was calculated by subtracting the preceding minimum amplitude from the thus found maximum amplitude. The 0.9–6.5-s analysis window was chosen based on the time course of SCRs (a 0.9–3.5 s latency to initiation [Sjouwerman & Lonsdorf, 2019] and a 1–3 s rise time to peak [Dawson, Schell, & Filion, 2000]). A trial was coded as a zero response if the maximum increase in amplitude was less than 0.01 μS, if the increase initiated later than 3.5 s after the stimulus onset, or if the increase was steady indicating a tonic change in skin conductance level. If there was an amplitude increase of 0.01 μS or more within a time frame of −1 to 0.9 s from the stimulus onset indicating a premature response unrelated to the stimulus, the trial was rejected (4.8% of all trials). Based on visual inspection, trials with excessive artifacts were rejected (1.4% of all trials). For each participant and for each condition, mean SCR magnitude was calculated by averaging the data from all accepted trials including those with zero responses (mean number of trials in each condition: $M_{\text{live}} = 15.1$, $M_{\text{videocall}} = 14.8$, $M_{\text{video}} = 15.1$). The mean SCR magnitudes were used in the statistical analyses.

2.4.2 | Facial muscle activity

Facial muscle activity was measured over the zygomaticus major and corrugator supercilii muscle regions. The skin over the recording sites was cleaned and slightly abraded with alcohol. For bipolar measurement, two 4 mm electrodes (Ag/AgCl) coated with electrode paste were attached 1 cm apart to the recording sites according to the guidelines by Fridlund and Cacioppo (1986).

Offline, the signal was filtered with a 10–499-Hz bandpass filter and a 50-Hz notch filter and rectified. Based on visual inspection, trials with artifacts due to excessive muscle movements and blinks were rejected (6.9% of all trials). One participant had less than 50% artifact-free epochs in one condition and she was excluded from the analysis. The signal was then segmented into 500-ms epochs from 500 ms prior to stimulus onset (baseline) to 5,000 ms after stimulus onset. The values were standardized within each participant and muscle site. Change scores were calculated by subtracting the baseline muscle activity from the average value of each 500-ms epoch and averaged across all accepted trials within each experimental condition (mean number of trials in each condition: $M_{\text{live}} = 14.8$, $M_{\text{videocall}} = 15.1$, $M_{\text{video}} = 14.8$). These change scores were used in the statistical analyses.

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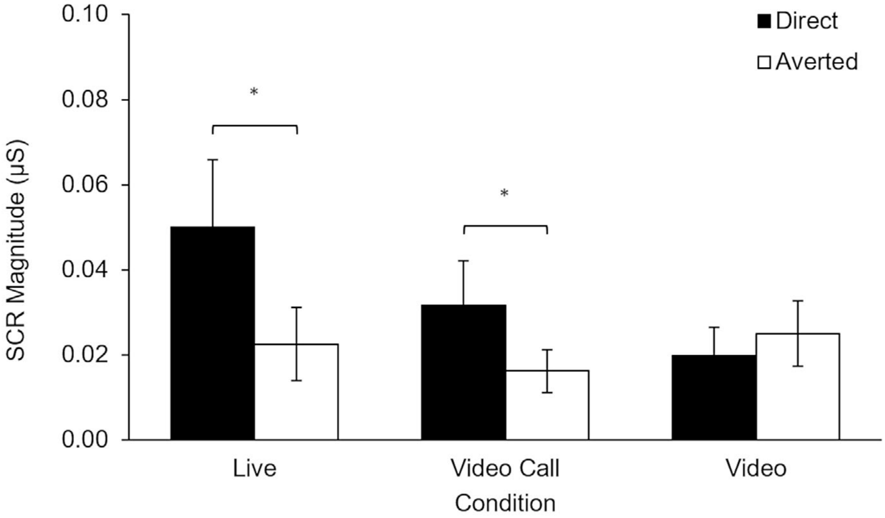

FIGURE 3 SCR magnitudes and standard errors of the mean (*SEM*) in response to direct and averted gaze within each condition.
$^*p < .05$, two-tailed *t* test

2.5 | Statistical analyses

Within-subjects analyses of variance (ANOVA) with condition (live vs. video call vs. video) and gaze direction (direct vs. averted) as within-subjects factors were used to compare the psychophysiological and subjective responses. In the EMG analysis, time (10 epochs, each lasting 500 ms) was used as a third within-subjects factor, because the time course of facial EMG responses can range from brief spikes to many seconds depending on the underlying emotional processes (Cacioppo, Martzke, Petty, & Tassinary, 1988). When the assumption of sphericity was violated, degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity. When a significant interaction between condition and gaze direction was observed, paired samples *t* tests were used to compare the responses to direct and averted gaze within each condition. Nonsignificant results from the *t* tests were further explored with the Two One-Sided Test (TOST) procedure with equivalence bounds set at $d = \pm 0.30$ (Lakens, 2017). For conciseness, additional analyses related to nonsignificant findings, nonparametric tests, and subjective ratings are reported in Appendix B in the online Supporting Information.

3 | RESULTS

3.1 | Skin conductance

A 2×3 (Gaze Direction × Condition) within-subjects ANOVA indicated a main effect of gaze direction, $F(1, 31) = 4.73$, $p = .037$, $\eta_p^2 = .13$. The SCR responses were greater in response to direct gaze ($M = 0.034$ μS, $SD = 0.045$, 95% CI [0.018, 0.050]) than to averted gaze ($M = 0.021$ μS, $SD = 0.027$, 95% CI [0.012, 0.031]). The main effect of condition, $F(2, 62) = 0.93$, $p = .399$, $\eta_p^2 = .03$, was not significant. Importantly, there was a statistically significant interaction between gaze direction and condition, $F(2, 62) = 4.49$, $p = .015$, $\eta_p^2 = .13$. When analyzing the three conditions separately, paired *t* tests indicated greater SCRs to direct versus averted gaze in the live condition, $t(31) = 2.57$, $p = .015$, $d = 0.45$, and in the video call condition, $t(31) = 2.15$, $p = .040$, $d = 0.38$, but not in the mere video condition, $t(31) = -0.69$, $p = .494$, $d = -0.12$. A TOST procedure indicated that the observed effect size was significantly within the upper bound of $d = 0.30$, $t(31) = 2.36$, $p = .012$, but not within the lower bound of $d = -0.30$, $t(31) = 1.03$, $p = .154$. Therefore, in the video condition, we can conclude that the perception of direct gaze did not elicit a meaningful increase in SCRs in comparison to averted gaze, but it is possible that it may have decreased the responses. See Figure 3 for SCR magnitudes in response to both gaze directions within each condition.

In order to compare the magnitude of SCR increase by direct gaze in the live and video call conditions, a 2 × 2 (Gaze Direction × Condition) within-subjects ANOVA was conducted. The main effect of gaze direction, $F(1, 31) = 8.22$, $p = .007$, $\eta_p^2 = .21$, was significant, whereas the main effect of condition, $F(1, 31) = 1.15$, $p = .292$, $\eta_p^2 = .04$, or the interaction between the two, $F(1, 31) = 1.35$, $p = .255$, $\eta_p^2 = .04$, were not. Differential responses were calculated by subtracting the SCRs in response to averted gaze from those to direct gaze within these conditions. Although no difference was observed in the magnitude of SCR increase by direct gaze between the live and video call conditions, $t(31) = 1.16$, $p = .255$, $d = 0.21$, a TOST procedure with equivalence bounds of $d = \pm 0.30$ did not support the absence of a meaningful difference between the conditions, $t(31) = 0.54$, $p = .298$.

3.2 | Facial muscle activity

Zygomatic EMG responses were analyzed with a 2 × 3 × 10 (Gaze Direction × Condition × Time) within-subjects ANOVA. Statistically significant main effects were found for gaze direction, $F(1, 30) = 18.34$, $p < .001$, $\eta_p^2 = .38$, and

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time, $F(3.99, 119.73) = 4.73$, $p = .001$, $\eta_p^2 = .14$ (Greenhouse–Geisser corrected, $\varepsilon = 0.44$), but not for condition, $F(2, 60) = 0.44$, $p = .649$, $\eta_p^2 = .01$. The zygomatic responses were greater in response to direct gaze ($M = 0.54$, $SD = 0.56$, 95% CI [0.34, 0.74]) than to averted gaze ($M = 0.21$, $SD = 0.40$, 95% CI [0.07, 0.35]), and the zygomatic activity increased as a function of time. Importantly, however, contrary to what was expected, there was no significant interaction between condition and gaze direction, $F(2, 60) = 0.30$, $p = .739$, $\eta_p^2 = .01$. No other significant interaction effects were found either (all ps > .10).

Corrugator region EMG responses were analyzed likewise with a 2 × 3 × 10 within-subjects ANOVA. The main effect of gaze direction was significant, $F(1, 30) = 8.00$, $p = .008$, $\eta_p^2 = .21$; corrugator responses were smaller in response to direct gaze ($M = -0.10$, $SD = 0.71$, 95% CI [−0.35, 0.15]) than to averted gaze ($M = 0.15$, $SD = 0.48$, 95% CI [−0.02, 0.31]). The main effects of condition, $F(2, 60) = 1.15$, $p = .324$, $\eta_p^2 = .04$, and time, $F(1.76, 52.69) = 1.22$, $p = .300$, $\eta_p^2 = .04$ (Greenhouse–Geisser corrected, $\varepsilon = 0.20$), were not significant. There was a significant two-way interaction between gaze direction and time, $F(2.90, 87.03) = 4.08$, $p = .010$, $\eta_p^2 = .12$ (Greenhouse–Geisser corrected, $\varepsilon = 0.32$). A closer look at the interaction revealed that the effect of time was not significant in the direct gaze trials, $F(1.73, 51.79) = 2.27$, $p = .120$, $\eta_p^2 = .07$ (Greenhouse–Geisser corrected, $\varepsilon = 0.19$), or in the averted gaze trials, $F(3.36, 100.85) = 2.12$, $p = .096$, $\eta_p^2 = .07$ (Greenhouse–Geisser corrected, $\varepsilon = 0.37$). A marginal two-way interaction was found between gaze direction and condition, $F(2, 60) = 3.05$, $p = .055$, $\eta_p^2 = .09$. No other significant interaction effects were found (all ps > .10). See Figure 4 for the EMG responses to both gaze directions within each condition.

3.3 | Subjective valence and arousal

Subjective ratings of affective valence and arousal were measured with the Self-Assessment Manikin in response to both gaze directions in all three conditions. 2 × 3 within-subjects ANOVAs indicated no significant main effects or interaction effects for either scale (all ps > .10). See Table 1 for the valence and arousal ratings in response to both gaze directions within each condition, and Appendix B for more detailed statistical information.

4 | DISCUSSION

The present study investigated the roles of being seen by another person and his or her physical presence in the psychophysiological responses to eye contact. For this purpose, we measured autonomic arousal with SCRs and facial EMG responses associated with positive affect to direct versus averted gaze in three different conditions: one with a live interaction, another with a video call interaction, and a third condition of merely watching a video of another person. Direct gaze was found to elicit greater SCRs indicating greater autonomic arousal than averted gaze in live interaction and in video call, but no such effect was observed in the mere video condition. The effect was of similar magnitude in the live and video call conditions. Regarding facial reactions, however, direct gaze elicited more positive affective facial reactions—greater zygomatic and smaller corrugator EMG activity—than averted gaze in all three conditions. No significant differences in subjective ratings of valence and arousal were found between gaze directions in these three conditions.

Participants' arousal responses to direct gaze were elevated only in the live and video call conditions. While merely watching a video of another person, the perceived gaze direction did not affect the participants' autonomic arousal. We, therefore, replicated previous findings of heightened autonomic arousal in live eye contact (e.g., Hietanen et al., 2008; Jarick & Bencic, 2019; Nichols & Champness, 1971; Pönkänen, Peltola, et al., 2011; Prinsen & Alaerts, 2019) and no increase in arousal in response to direct versus averted gaze presented in video (Leavitt & Donovan, 1979; Lyyra et al., 2018; Wieser et al., 2009). As being seen by the other person was the common denominator between the live and video call conditions, the results also converge with the findings of Myllyneva and Hietanen (2015) wherein direct gaze was shown to elicit greater arousal than averted gaze only when participants believed to be seen by the other person.

The live and video call conditions also differ from the mere video condition in the possibility for subtle nonverbal interaction. Although the models were instructed to stay motionless and expressionless and not to reciprocate with the participants verbally or nonverbally, in these two conditions, limited interactional contingencies, such as the model blinking as a reaction to something the participant did, were possible. Thus, it is possible that subtle nonverbal reactions could also explain the autonomic arousal responses to direct versus averted gaze in the live and video call conditions. However, this does not seem likely, because in the study by Myllyneva and Hietanen (2015) only participants' belief of being seen was manipulated and the models were, in fact, always able to see and, thus, react to, the participants' actions, and yet, the autonomic responses were greater to direct than averted gaze only when participants believed to be seen. Therefore, the most probable explanation for the present and previous results is that the autonomic arousal response to direct gaze is elicited by an experience of being seen by another individual.

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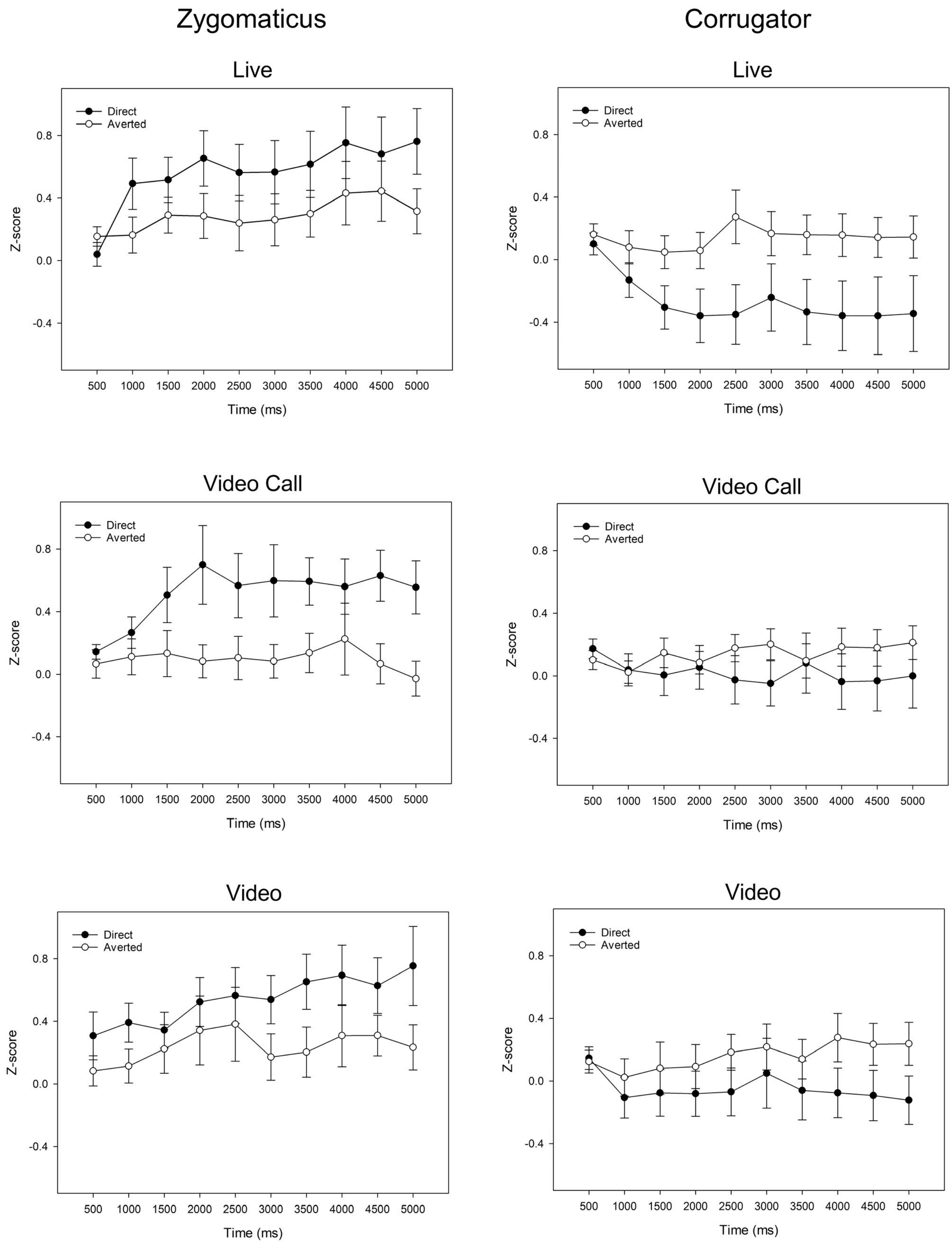

FIGURE 4 Standardized mean zygomatic and corrugator EMG responses (and *SEM*) in response to direct and averted gaze within each condition

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TABLE 1 Mean scores and standard deviations on the Self-Assessment Manikin by gaze direction and condition

	Live				Video call				Video			
	Direct		Averted		Direct		Averted		Direct		Averted	
Scale	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Valence	6.28	1.49	6.09	1.53	6.22	1.48	5.72	1.51	6.16	1.74	5.88	1.72
Arousal	2.63	1.60	2.38	1.19	2.38	1.41	2.50	1.11	2.44	1.41	2.44	1.39

Note: 95% confidence intervals for the mean values are presented in Appendix B.

Most importantly, the present study extends the knowledge of what underlies the eye contact effects. Previous studies have observed this increase in arousal only in response to the gaze of another person present in the same room, and therefore, it has been unclear whether or not the other person's physical presence is also required for the effect (Helminen, Kaasinen, & Hietanen, 2011; Hietanen et al., 2008, 2018; Jarick & Bencic, 2019; Myllyneva & Hietanen, 2015, 2016; Myllyneva, Ranta, & Hietanen, 2015; Nichols & Champness, 1971; Pönkänen, Peltola, et al., 2011). By showing that the perception of direct gaze elicits a greater arousal response than averted gaze also in a video call interaction, the present study is the first to demonstrate that another person's physical presence is not required for the effect.

The present results have importance also for social cognition research more generally. In studies of social cognition, participants are often presented with pictures or videos of other people in order to achieve high controllability of stimulus presentation. Importantly, however, pictorial stimuli do not allow any actual interaction between the observer and the stimulus persons. In recent years, the use of such spectatorial settings has been criticized for this limitation (Risko, Laidlaw, Freeth, Foulsham, & Kingstone, 2012; Risko, Richardson, & Kingstone, 2016). Schilbach and colleagues (2013), for example, argued for an approach to the investigation of social cognition that is based on interaction rather than sheer observation. Our findings support such a second-person approach by demonstrating that the perception of another person on a computer screen does not have the same effect on autonomic nervous system if the perception is not equipped with a bidirectional exchange of gaze with another conscious mind.

The facial EMG measurements indicated that the perception of direct gaze elicited an increase in zygomatic and decrease in corrugator muscle activity as compared to averted gaze. This effect was found in all conditions regardless of whether the seen face was that of a live person or one on a computer screen and whether the other person was able to see the participant or not. Similar facial EMG responses to a live person's direct versus averted gaze have also been observed before (Hietanen et al., 2018), but as far as we know, this is the first study to compare the affective facial responses to different presentation forms of direct and averted gaze stimuli. The present results indicate that, contrary to the arousal responses, the facial reactions are elicited by the mere perception of direct gaze and they are not moderated by the experience of being seen.

The discrepancy between autonomic arousal and facial reactions importantly implies that the activation of the zygomatic muscle and the relaxation of the corrugator muscle do not necessarily reflect a genuine affective experience. These EMG responses are associated with positive emotional reactions (e.g., Dimberg, Thunberg, & Grunedal, 2002), but they may also reflect communication of social motives (e.g., Parkinson, 2005). Hietanen and colleagues (2018) proposed that enhanced zygomatic activity to another person's direct gaze may be caused by a highly automatized affiliative response, a learned reaction of smiling to the perception of a face looking your way. The present results lend further empirical support to their proposal because the facial reactions were dissociated from emotional arousal and because they were also observed in a context where bidirectional communication was not possible.

Subjective evaluations of valence and arousal were not found to differ between the gaze directions or conditions. This was unexpected and in contrast to the psychophysiological measurements, although similar inconsistencies have been observed before (e.g., Rosebrock, Hoxha, Norris, Cacioppo, & Gollan, 2016). The present results also contradict previous findings from our own laboratory that have found a small but significant gaze direction effect on both scales (Hietanen et al., 2008; Pönkänen, Alhoniemi, et al., 2011). One possible explanation for this discrepancy is that, after the block during which the physiological responses were recorded, participants were instructed to assess their emotional experience during the subsequent presentations, and then, presented with the faces again. In the previous studies, participants were asked to respond just based on recall of how they felt while seeing the faces during the preceding stimulus block. It is plausible that an online evaluation of valence and arousal during stimulus presentations leads to different responses than an evaluation based on recall of previous emotional states. Another possible explanation stems from the large number of trials that preceded the evaluation. In the present study, participants were presented with the same stimulus face a much larger number of times (even as many as 91 times in the last condition) before the evaluations, which could have caused habituation to

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the stimulus. Overall, it seems possible that factors related to the study design may explain this discrepancy.

One limitation of this study is that we cannot conclude that the other person's physical presence had no additive effect on autonomic arousal even though no such effect was observed. There was no significant difference in the magnitude of SCR increase by direct versus averted gaze between the video call and live conditions. However, an equivalence test indicated that the present data do not have the statistical power to compellingly show that the other person's physical presence has no additive effect on the responses. In further research, a larger sample is required to investigate this question. Nevertheless, the present data do show that the other person's presence is not required for the arousal effect, and that the additive effect of physical presence is either small or nonexistent.

The present study design imposes some limitations on the implications of the results. First, because only two different types of affect-related psychophysiological responses were measured, this study should not be considered a thorough comparison of the emotional effects of live and video call interaction, and further research on these effects is warranted. Second, it is unclear whether the EMG responses would be similar in response to the face of a person of the opposite sex. This is because we used models of the same sex as the participants, and, to our knowledge, these EMG responses to eye contact have only been observed in one other study, wherein the models were also of matching sex (Hietanen et al., 2018). Third, the conclusions do not necessarily extend to the use of common, present-day videoconferencing technologies because, in these applications, the users usually see each other with a slightly averted gaze due to a mismatch between the positioning of the camera and the location of the partner's eye region on the screen. Fourth, in the present study, affect-related psychophysiological responses were investigated in a very simplified situation. Therefore, it remains for further research to determine whether responses to video call interactions differ from live encounters in more complex forms of social interaction such as, for example, psychological interventions or collaborative work. All that being said, the present findings do tentatively suggest that an interaction in a face-to-face context and over a video call may have similar effects on affective arousal.

In conclusion, the present study demonstrated that the autonomic arousal effect of eye contact is similar in live and video call interactions, but not observed in response to a visually similar video presentation of direct versus averted gaze. Thus, in the present data, being seen by the other person was an essential prerequisite for the effect, whereas the other person's physical presence was not. In addition, affiliative facial reactions were observed in all conditions, and hence they seem to be automatically elicited by the mere perception of direct gaze. As John Heron (1970) beautifully stated, mutual gazing "constitutes the dramatic élan of true encounter between persons" (p. 255). What the present study shows is that this energetic power of eye contact is so strong that it may even overcome the constraints of physical distance.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest related to this study.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information section.

Appendix A. Self-referential processing and self-awareness

Appendix B. Supplementary results

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