Tampere University

JONNE O. HIETANEN

All Eyes on Eye Contact

Studies on cognitive, affective and behavioral effects of eye contact

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Responsible supervisor and Custos	Professor Jari Hietanen Tampere University Finland	
Supervisor	Docent Mikko Peltola Tampere University Finland	
Pre-examiners	Professor Niklas Ravaja University of Helsinki Finland	Assistant Professor Michelle Jarick MacEwan University Canada
Opponent	Professor Anne Böckler-Raettig Leibniz University Hannover Germany	

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"Being-seen-by-the-Other" is the truth of "seeing-the-Other."

—Jean-Paul Sartre, *Being and Nothingness*

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ABSTRACT

Gaze direction and eye contact are important social cues. Eye contact is known to have various effects on cognition, affect, and behavior, though many aspects of these effects and what underlies them is unclear. The perception of direct gaze has been proposed to elicit self-referential cognitive processing of external information, which could account for many other effects of eye contact. However, this proposed effect has not been previously investigated. This was examined in Study I by using implicit measures based on pronoun selection. Genuine eye contact with another live person was found to elicit self-referential processing, but in two other experiments wherein videos of direct and averted gaze were used as stimuli, this effect was not observed. This suggests that being seen by another person may be important for the effect.

Study II examined the roles of being seen by the other person and their physical presence on the effects of eye contact. For this aim, psychophysiological and behavioral responses to direct and averted gaze were compared in live interaction, in video call interaction, and while merely watching a video presentation of the other. The autonomic arousal response to eye contact was found to depend on being seen by the other person but not their physical presence. Affiliative facial reactions, by contrast, were elicited in response to the mere perception of direct gaze regardless of being seen by the other or their presence. Unexpectedly, on a measure of self-referential processing, responses to direct gaze were similar in the three conditions.

Study III investigated the effect of eye contact on lying. Previous studies have shown that seeing a picture of watching eyes can reduce dishonest behavior. It is, however, unclear whether this effect extends to in-person eye contact or to actual lying. This was investigated with an interactive computer game, which participants played against a confederate of the experimenter. Seeing the opponent's direct gaze in comparison to their averted gaze was found to reduce subsequent lying.

The present results broaden the knowledge of the effects of eye contact and of their underlying mechanisms. Most importantly, they suggest that seeing another person's direct gaze increases self-referential processing and reduces lying, and that the autonomic arousal response to eye contact depends on being seen by the other person but not their physical presence. Together, these studies elucidate the multifaceted and context-dependent nature of the eye contact effects.

TIIVISTELMÄ

Katseen suunta ja katsekontakti ovat tärkeitä sosiaalisia viestejä. Katsekontaktin tiedetään vaikuttavan tiedonkäsittelyyn, tunteisiin ja käyttäytymiseen, mutta moni asia katsekontaktin vaikutuksista ja vaikutusten mekanismeista on yhä epäselvä.

Suoran katseen havaitsemisen on ehdotettu aktivoivan itseen liittyvää kognitiivista prosessointia, joka voisi selittää monia katsekontaktin vaikutuksista. Ilmiötä ei kuitenkaan ole aiemmin tutkittu. Tutkimuksessa I tarkasteltiin katsekontaktin vaikutusta itseen liittyvään prosessointiin käyttämällä implisiittistä, persoonapronominien valintaan perustuvaa mittaria. Aidon katsekontaktin havaittiin lisäävän itseen liittyvää prosessointia. Sen sijaan kahdessa kokeessa, joissa ärsykkeinä käytettiin suoraa ja käännettyä katsetta esittäviä videoita, vaikutusta ei tullut esiin. Tulokset viittaavat siihen, että tämä vaikutus voi edellyttää toisen ihmisen katseen kohteena olemista.

Tutkimuksessa II tarkasteltiin toisen ihmisen katseen kohteena olemisen ja hänen fyysisen läsnäolonsa merkitystä katsekontaktin aiheuttamiin vaikutuksiin. Suoran ja käännetyn katseen havaitsemisen aiheuttamia psykofysiologisia vasteita ja käyttäytymisen muutoksia mitattiin kasvokkaisessa vuorovaikutustilanteessa, videopuhelutilanteessa ja tilanteessa, jossa tutkittavat vain katselivat toista ihmistä tietokoneen ruudulta ilman kaksisuuntaista yhteyttä. Katsekontakti aktivoi autonomista hermostoa, ja tämän havaittiin edellyttävän toisen katseen kohteena olemista, mutta ei hänen fyysistä läsnäoloaan. Kasvolihasten aktivaatiossa sen sijaan suoran katseen havaitseminen aiheutti hymyyn viittaavia reaktioita riippumatta siitä, kykenikö toinen henkilö näkemään tutkittavaa tai oliko hän samassa tilassa tutkittavan kanssa. Odotusten vastaisesti tutkittavien vastaukset itseen liittyvän prosessoinnin mittarissa eivät eronneet eri tilanteiden välillä.

Tutkimuksessa III selvitettiin katsekontaktin vaikutuksia valehtelemiseen. Aiemmissa tutkimuksissa on osoitettu, että suoraa katsetta esittävät kuvat voivat vähentää epärehellistä käyttäytymistä. Ei kuitenkaan tiedetä, ilmeneekö sama vaikutus myös luonnollisessa vuorovaikutuksessa tai voiko katseen havaitseminen vähentää toiselle ihmiselle valehtelemista. Tätä tutkittiin vuorovaikutteisella tietokonepelillä, jota tutkittavat pelasivat tutkimusavustajaa vastaan. He luulivat tutkimusavustajan olevan toinen tutkimukseen osallistuja. Pelikierroksilla, joita

ennen tutkittavat olivat nähneet vastapelaajan katsovan suoraan kohti, he valehtelivat vähemmän kuin kierroksilla, joita ennen vastapelaaja oli katsonut alaviistoon.

Tämän väitöskirjan tulokset laajentavat aiempaa ymmärrystä katsekontaktin vaikutuksista ja niiden mekanismeista. Tulokset viittaavat siihen, että toisen ihmisen suora katse aktivoi itseen liittyvää kognitiivista prosessointia ja vähentää valehtelemista. Lisäksi havaittiin, että katsekontaktin aiheuttama autonomisen hermoston virittyminen edellyttää toisen ihmisen katseen kohteena olemista, mutta ei hänen fyysistä läsnäoloaan. Yhdessä nämä tulokset ilmentävät katsekontaktin vaikutusten moninaista ja tilannesidonnaista luonnetta.

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ABBREVIATIONS

ANOVA	Analysis of variance
CI	Confidence interval
EEG	Electroencephalography
EMG	Electromyography
ERP	Event-related potential
ISI	Interstimulus interval
LFQ	Lying Frequency Questionnaire
LIF	Linguistic Implications Form
SAM	Self-Assessment Manikin
SCR	Skin conductance response
SEM	Standard error of the mean
SSAS	Situational Self-Awareness Scale
TOST	Two One-Sided Test procedure
VR	Virtual reality

ORIGINAL PUBLICATIONS

I Hietanen, J. O., & Hietanen, J. K. (2017). Genuine eye contact elicits self-referential processing. *Consciousness and Cognition, 51,* 100–115. https://doi.org/10.1016/j.concog.2017.01.019

II Hietanen, J. O., Peltola, M. J., & Hietanen, J. K. (2020). Psychophysiological responses to eye contact in a live interaction and in video call. *Psychophysiology, 57*(6), Article e13587. https://doi.org/10.1111/psyp.13587

III Hietanen, J. O., Syrjämäki, A. H., Zilliacus, P. K., & Hietanen, J. K. (2018). Eye contact reduces lying. *Consciousness and Cognition*, *66*, 65–73. https://doi.org/10.1016/j.concog.2018.10.006

1 INTRODUCTION

Eye contact has an important role in social interaction. When two people are facing each other, they often direct their gaze to the interlocutor's eyes (Itier et al., 2007). Another person's eye region provides information about their intentions and emotional state (George & Conty, 2008). By looking at the other's eyes and seeing their gaze direction, one is also able to infer the direction of their attention (Itier & Batty, 2009). When another person's gaze is directed to one's self, it is usually interpreted as a positive social signal, such as a communicative intent or an expression of positive feelings (for a review, see Kleinke, 1986). This is in contrast to many other animals that perceive eye contact as a threat (Emery, 2000). Overall, people who use eye contact are evaluated as more attentive, pleasant, attractive, and credible than those who avoid it (Kleinke, 1986). Interestingly, some effects of eye contact are not limited to face-to-face interactions, and just seeing a picture of a face with direct gaze has been found to have many effects on cognition, emotion, and behavior. For example, the mere perception of such a picture has been shown to increase awareness of one's bodily sensations (Baltazar et al., 2014). Some effects, however, such as heightened autonomic arousal and awareness of one's appearance, seem to occur only in genuine, in-person eye contact, and not in response to mere pictures (e.g., Pönkänen, Peltola, & Hietanen, 2011). This implies that different effects of eye contact may have different underlying mechanisms. In the recent two decades, there has been a surge of research on the effects of eye contact. Although a lot has been already discovered, many questions remain unresolved regarding how the perception of eye contact affects its observer and what underlies these effects.

The aim of this dissertation is to investigate the effects of eye contact and the conditions required for their elicitation. The dissertation includes three publications. Study I investigated whether the perception of direct gaze influences self-referential cognitive processing. In Study II, the emotional and cognitive effects of eye contact and the roles of being seen by the other person and their physical presence on these effects were examined. Study III, in turn, focused on the effect of eye contact on lying. What follows is a review of relevant previous research on these topics to provide a rationale for the present studies.

1.1 Eye contact and self-referential processing

For long, it has been theorized that eye contact increases awareness of one's self (e.g., Argyle, 1988). Based on emotional reactions that infants show, eye contact has been proposed to evoke awareness of the self as an object of others' attention even at the very early age of two months (Reddy, 2003). Seeing another person gazing at an object tends to orient the attention to the same target (e.g., Driver et al., 1999). It follows logically then that, if the other's gaze is directed to one's self, one's attention should similarly turn to the self. In support of this proposal, studies have shown that eye contact does increase public self-awareness, awareness of how one appears to others (Hietanen et al., 2008; Myllyneva et al., 2015; Myllyneva & Hietanen, 2015; Pönkänen, Peltola, & Hietanen, 2011). Overall, however, the effect of eye contact on self-awareness has been little studied and mostly with self-report questionnaires.

In addition to heightened public self-awareness, eye contact may have a much wider effect on self-related cognition. Conty and colleagues (2016) proposed that the perception of another's direct gaze, or eye contact, has self-referential power–capacity to enhance self-referential cognitive processing. Self-referential processing means processing of external information in relation to the self, which can thus facilitate and integrate perception and memory (Sui & Humphreys, 2015). In recent decades, self-referential processing has been the target of a lot of research. It has been found to have a neuropsychological basis involving especially the medial cortical areas of the brain, and many now consider self-referential processing to be in the core of what is called the self (Northoff et al., 2006). Conty and colleagues (2016) argued that if eye contact can increase self-referential processing, it could comprehensively explain many of the eye contact effects, such as heightened self-awareness, enhanced memory for contextual information, more positive evaluation of other people, and activation of prosocial behavior. Moreover, they proposed that even the perception of a mere image of watching eyes could have a similar effect. They argued that, because of both human evolution and repeated learning experiences in early life, a sense of being watched is an intrinsic property of any perception of watching eyes regardless of whether one is actually being observed by another person. There is, in fact, some evidence suggesting that a mere image of watching eyes can induce a sense of being seen (Pfattheicher & Keller, 2015). If a watching-eyes image can increase self-referential processing, this could account for many of the eye contact effects that have been demonstrated with mere images, such as enhanced memory performance (Hood et al., 2003) and increased prosocial behavior (e.g., Manesi et al., 2016).

Such an extensive account is intriguing, yet the effect of eye contact on self-referential processing has not been directly studied. As mentioned, some studies have demonstrated an effect of eye contact on public self-awareness, which can be interpreted as evidence of enhanced self-referential processing (Hietanen et al., 2008; Myllyneva et al., 2015; Myllyneva & Hietanen, 2015; Pönkänen, Peltola, & Hietanen, 2011). These studies, however, have some notable limitations. They have relied exclusively on self-report questionnaires, the validity of which may be limited by participants' capacity and willingness to accurately evaluate and honestly report their own state (Paulhus & Vazire, 2007). Particularly problematic for the measurement of self-awareness is that completing self-report questionnaires can in and of itself increase self-awareness (Osberg, 1985), presumably because of the introspection they require (Eichstaedt & Silvia, 2003). This may thus reduce the sensitivity of self-report measurement of self-awareness. Importantly, however, two studies have shown a direct gaze effect on self-related cognition without relying on self-report measurement (Baltazar et al., 2014; Isomura & Watanabe, 2020). In these studies, the perception of a direct gaze image in comparison to that of an averted gaze image was found to improve participants' ability to accurately evaluate their interoceptive signals, that is to say, heartbeat and level of physiological arousal. Because self-referential processing is associated with improved interoceptive accuracy (Ainley et al., 2013), these results have been interpreted to indicate an increase in self-referential processing by eye contact (Isomura & Watanabe, 2020). However, it is still only indirect evidence of the self-referential processing effect, because sharpened interoception is a very specific aspect of, or possibly just an associated phenomenon to, self-referential processing. So far, no study has directly investigated whether eye contact induces self-referential processing. This was the main aim of Study I.

1.2 Emotional effects of eye contact

Eye contact has been found to affect the emotional experience and affective physiology of its perceiver (for a review, see Hietanen, 2018). Maybe the most robust of these effects is the increase in affective arousal by eye contact. Affective arousal refers to the energetic level of emotional experience and seeing another person's direct versus averted gaze has been consistently observed to elicit greater skin conductance responses (SCRs) indicating increased physiological arousal (e.g., Nichols & Champness, 1971). Sweating is controlled by the sympathetic branch of the autonomic nervous system, and an increase in skin conductance is a reliable indicator of sympathetic nervous system activity (Critchley, 2002). Studies employing other methods, such as measurement of pupil dilation and brain imaging to gauge amygdala activation, have likewise shown an increase in affective arousal by the perception of direct gaze (Porter et al., 2006; Kawashima et al., 1999). Participants' subjective evaluations also correspond to these results (e.g., Chen, Peltola, et al., 2017; Pönkänen, Alhoniemi, et al., 2011).

Another aspect of an affective reaction is valence, its positivity or negativity, and implicit measures suggest that eye contact is associated with positive affect. Valence of automatic affective reactions can be studied by measuring the electromyographic (EMG) activity of facial muscles. The perception of positive stimuli is associated with the activity of *zygomaticus major* muscles (the smile muscles, required to draw the corners of the mouth upward) and negative stimuli with the activity of *corrugator supercilii* muscles (the frown muscles, required to draw the eyebrows downward) (Cacioppo et al., 1986). Seeing another person's direct gaze has been found to increase zygomatic activity and decrease corrugator activity in comparison to seeing the person with averted gaze thus indicating a positive affective response to eye contact (Hietanen et al., 2018). Similarly, studies employing measures of implicit associations have shown that direct gaze is more congruent with positive than with negative words suggesting a positive affective evaluation (Chen, Helminen, & Hietanen, 2017; Lawson, 2015). Interestingly, however, when study participants have been asked to assess affective valence subjectively, they have often reported experiencing *less* positive valence during eye contact than while seeing the other person avert their gaze (Chen, Helminen, & Hietanen, 2017; Hietanen et al., 2008; Pönkänen, Alhoniemi, et al., 2011). Pönkänen, Alhoniemi, and others (2011) suggested that this may reflect a feeling of unease caused by being watched by another person. Hietanen (2018) further argued that the discrepancy between implicit and explicit results may be explained by an initially positive response being followed by more negative affect due to self-evaluation. As noted earlier, eye contact may increase self-awareness, which, in turn, has been associated with self-evaluation (Duval & Wicklund, 1972). If eye contact induces self-evaluative thoughts, this could explain participants' reports of less positive affect during eye contact than while seeing an averted gaze and the contrast between self-evaluations and psychophysiological responses.

Another line of psychophysiological research has investigated affective reactions by measuring asymmetric frontal cortical activity (for a review, see Harmon-Jones et al., 2010). Early research suggested that relatively greater left-sided than right-sided frontal cortical activity indicates positive affect. However, a more recent view suggests that this asymmetric activity actually reflects the motivational direction of an affective reaction, that is, the tendency to move toward or away from the object. In this view, approach motivation is related to greater left than right prefrontal cortex activity (and vice versa for avoidance motivation). In most studies, these effects have been measured by using electroencephalographic (EEG) recordings of frontal asymmetry in alpha-band activity. Studies investigating the effects of eye contact with this measure have found that another person's direct gaze elicits frontal asymmetry indicative of increased approach motivation and averted gaze elicits asymmetry indicative of increased avoidance motivation (Hietanen et al., 2008; Kylliäinen et al., 2012; Pönkänen, Peltola, & Hietanen, 2011). This effect, however, has not been consistently observed, and it may be moderated by individual differences, such as personality (Pönkänen & Hietanen, 2012; Uusberg et al., 2015).

Taken together, studies suggest that the affective reaction induced by eye contact can be characterized by heightened arousal and probably by a tendency to approach. The automatic affective response to eye contact seems to be positive, although the inherent valence of it is more complicated a question and may depend on self-awareness and self-evaluation.

1.3 The role of being seen

Many of the eye contact effects, like fast detection (Conty et al., 2006) and enhanced memory of a face with a direct gaze (Hood et al., 2003), have been demonstrated by presenting participants with pictures of direct gaze. To account for these results, Senju and Johnson (2009) presented a fast-track modulator model of gaze perception. They hypothesized that a fast, subcortical pathway, involving superior colliculus, pulvinar, and amygdala, initially detects eye contact based on coarse visual information. This pathway then projects to cortical areas in the social brain network, which includes the fusiform gyrus, parts of the superior temporal sulcus, and medial prefrontal areas. Via these projections, the subcortical structures are then able to modulate further processing of the sensory information. The model implies that the eye contact effects depend, first and foremost, on the perception of certain visual configurations. Hence, the model may be considered as a theoretical foundation for why the eye contact effects are expected to arise by the perception of direct gaze, even when it is presented in a picture.

In recent years, however, many researchers have begun to criticize the use of pictures in eye contact research. Risko and others (2012) pointed out that, although studies using pictorial stimuli are valuable, the difference between looking at a picture of another person and being in a face-to-face interaction with them is so drastic that the results may not extend from the first to the latter. For this reason, they encouraged social cognition researchers to explicitly compare the effects of live and pictorial stimuli. On the same vein, Schilbach and colleagues (2013) argued that social cognition is fundamentally different in actual interaction than while merely observing other people and it should thus be studied in an interactive manner, which may provide radically new insights.

Some studies had, in fact, already examined the role of social interaction on eye contact effects by contrasting the perception of a live person with that of a picture (Hietanen et al., 2008; Pönkänen, Alhoniemi et al., 2011; Pönkänen, Peltola, & Hietanen, 2011). These studies have shown that, in comparison to the view of another's averted gaze, eye contact elicits greater SCRs, relatively greater left-sided than right-sided frontal brain activity, higher evaluations of public self-awareness, higher ratings of arousal, and lower ratings of valence. All of these effects were limited to the perception of a live person and not observed in response to a mere picture of direct gaze. In accordance with these results, most studies that have used only pictorial stimuli have found no significant difference in arousal responses (SCRs or pupillary responses) between the perception of direct and averted gaze (Joseph et al., 2008; Kampe et al., 2003; Leavitt & Donovan, 1979; Lyyra et al., 2018; Wieser et al., 2009), although some have observed a heightened arousal response to direct gaze pictures in certain study conditions (Conty, Russo, et al., 2010; Kylliäinen & Hietanen, 2006; Porter et al., 2006; Soussignan et al., 2013). Furthermore, in facial EMG studies, responses associated with positive emotion have been observed by presenting participants with a live face with a direct gaze and a neutral expression (Hietanen et al., 2018), whereas studies using similar direct versus averted gaze stimuli in pictures have not found the same effect (Mojzisch et al., 2006; Rychlowska et al., 2012; Schrammel et al., 2009; Soussignan et al., 2013). Overall, these studies clearly suggest that being actually faced with another person is indeed fundamentally different from the perception of their picture. Moreover, differences between these two situations may provide the key to understanding what gives rise to many of the eye contact effects.

The essential difference between eye contact in face-to-face interaction and the mere perception of a direct gaze picture is that, in the latter, there is no one looking back. Myllyneva and Hietanen (2015) have directly investigated the role of being seen on eye contact effects. 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 window in between them. In both study conditions, participants' view of the other person was identical and only their belief of whether the other person could see them differed. Autonomic arousal responses (SCRs), psychophysiological orienting responses (heart rate deceleration and frontal P3 event-related potentials [ERPs]), and self-evaluations of public self-awareness were higher in response to direct versus averted gaze only when participants believed that the other person could see them. A recent study corroborated this finding by showing that prolonged eye contact elevated participants' skin conductance level only when it was bidirectional, that is, when a participant was both seeing and being seen by another person, and not when either variable was lacking (Jarick & Bencic, 2019). Taken together, these results provide considerable evidence that being seen by the other person is an essential prerequisite for many of the effects of eye contact.

Another difference between looking at a picture and a live person is the physical presence of the other person. All the aforementioned studies with live stimuli employed study designs where the other person was present in the same room. This raises the question of whether the physical presence of the other is also required for the elicitation of these effects. Notably, though, the results of one study that examined the effect of eye contact over an alleged online video connection suggests that it may not be (Hazem et al., 2017). In that study, participants were found to have more accurate interoceptive awareness after seeing another person and believing that the other person was able to see them than after the same view without a belief of being seen. This implies that a belief of being seen may be more important for the interoceptive awareness effect than the physical presence of the other. However, because these conditions were not compared to an in-person interaction, it is unclear whether the effects of an online connection are equal to those elicited by a face-to-face encounter with the other person present in the same physical space. No previous study has directly investigated what role the other person's physical presence plays on the effects that eye contact evokes. Moreover, as only interoceptive awareness was measured and different effects of eye contact may have different underlying mechanisms, it remains unclear what role the other's presence plays in other effects, such as the affective responses to eye contact. Answering this question was the aim of Study II of this dissertation.

1.4 Eye contact and dishonesty

One interesting effect of seeing watching eyes is that it seems to increase prosocial behavior and decrease dishonest behavior (e.g., Bateson et al., 2006; Oda et al., 2011). People seem to care about their reputation and, if they feel that others are observing them, they tend to behave in a more socially desirable way. Studies also suggest that self-referential processing is associated with heightened awareness of social evaluation (Banerjee et al., 2012) and inversely associated with malicious behavior (Cikara et al., 2014). Based on these associations, Conty and others (2016) have argued that an increase in self-referential processing by eye contact could also explain the effect. As noted earlier, they proposed that even a mere watching-eyes image should increase self-referential processing, which could therefore explain why a sheer image seems to suffice for the effect. Studies have shown that seeing an image of watching eyes increases prosocial behavior, such as giving money to charities (Powell et al., 2012), and reduces undesirable behavior, like taking drinks without paying (Bateson et al., 2006) and stealing bicycles (Nettle et al., 2012).

Notably, however, most of these studies have focused on prosocial behavior and relatively few have investigated how the perception of watching eyes affects dishonest behavior (Ayal et al., in press; Bateson et al., 2006; Cai et al., 2015; Nettle et al., 2012; Oda et al., 2015; Pfattheicher et al., 2019; Siebenaler et al., 2018). Moreover, some of these studies have not found the effect (Cai et al., 2015; Pfattheicher et al., 2019) or only found a decrease in dishonest behavior when the watching eyes are equipped with a persuasive message (Ayal et al., in press). Furthermore, these studies have examined many aspects of dishonesty, but the effect of another person's gaze direction on actual lying in a face-to-face interaction has not been previously studied.

Most previous studies have used eye images, and, as discussed earlier, the effects of seeing a real person's direct gaze are different from those elicited by the perception of a direct gaze picture (Hietanen et al., 2008; Pönkänen, Alhoniemi, et al., 2011; Pönkänen, Peltola, & Hietanen, 2011; Prinsen & Alaerts, 2019). The effects observed with pictures should not be automatically expected to extend to interactive situations (Risko et al., 2012), and a live person's gaze could arguably have a different, possibly stronger, effect on one's behavior than a mere watching-eyes image. Accordingly, even by making the watching-eyes image more realistic seems to enhance its effect on dishonest behavior (Siebenaler et al., 2018).

Moreover, lying directly to another person differs in many ways from the aforementioned forms of dishonest behavior. In direct lying, the recipient of the dishonest action is much more salient and clearly defined than a vague idea of a possible sufferer. Knowing who the recipient is has been shown to reduce lying to them (Van Zant & Kray, 2014). Studies have also shown that people lie more in a video-based interaction than in a face-to-face interaction, and even more in a text-based interaction (Rockmann & Northcraft, 2008; Zimbler & Feldman, 2011). In an interactive situation, the recipient is also able to express doubts, which may further reduce the inclination for dishonesty.

Another important limitation of most previous studies is that they have compared the picture of watching eyes to a completely different kind of image, like a picture of flowers (e.g., Bateson et al., 2006). Despite this, the effect has been attributed to the perception of watching eyes and not to the perception of a human face. Notably though, one study has avoided this pitfall and demonstrated an increase in prosocial behavior (i.e., helping of others) by the perception a direct gaze image as compared to seeing images of an averted gaze, closed eyes, or a flower (Manesi et al., 2016).

The aim of Study III of this dissertation was to extend the knowledge of the watching-eyes effect on dishonesty by investigating it in an interactive situation where the effects of another live person's direct and averted gaze on lying were compared.

1.5 The present studies

The studies of this dissertation intended to answer the following questions. First, does eye contact induce self-referential processing? Second, what are the roles of being seen by another person and their physical presence on the effects of eye contact? Third, does eye contact reduce lying?

In Study I, the effect of eye contact on self-referential processing was investigated by using linguistic tasks. Some previous studies have cleverly measured self-focused attention by the frequency of first-person singular pronoun use in such tasks. Davis and Brock (1975) have devised a task in which participants read sentences written in a language they do not understand believing that the task is a measure of sensitivity to foreign languages. The person pronouns in the incomprehensible sentences are underlined, and the task is to guess which English pronouns correspond to the underlined words. They found that a sense of being observed (i.e., being in front of a camera) increased the use of first-person singular pronouns by 30 percent in comparison to a control condition. Wegner and Giuliano (1980, 1983) have developed a similar pronoun-selection task, the Linguistic Implications Form (LIF).

In the LIF, participants read sentences in their mother tongue that each have a blank in place of a person pronoun and fill in the blanks by choosing from three grammatically correct alternatives. Participants are instructed to choose the person pronoun they feel best fits the sentence. The LIF has been found to be sensitive to various manipulations of self-awareness, such as writing about oneself or running in place in an embarrassing way (Salovey, 1992; Silvia & Abele, 2002; Silvia & Eichstaedt, 2004; Snow et al., 2004; Wegner & Giuliano, 1980, 1983). Because increased use of self-referring pronouns reflects increased accessibility of self-related cognitions (Wisman et al., 2015) and because both of these tasks measure self-related interpretation of ambiguous information, they can, arguably, be used to measure self-referential processing. In Study I, participants were randomly assigned to either a direct gaze or an averted gaze group. They were alternatingly presented with a face and pronoun-selection task items. Depending on participants' group assignment, the face was always looking either directly at them or downward. In Experiments 1a and 1b, the stimulus was a video of another person presented on a computer screen for five seconds at a time (Experiment 1a) or one second at a time (Experiment 1b). In Experiment 2, a research assistant acted as a model, and their face served as the stimulus. The live stimulus was presented through a liquid-crystal shutter window for five seconds at a time. Self-referential processing was measured as the use of first-person pronouns on these tasks. In all experiments, self-referential processing was expected to be higher in the direct gaze group than the averted gaze group.

In Study II, affective and cognitive responses to eye contact and the roles of being seen by the other person and their physical presence on these effects were investigated. For this purpose, responses to direct and averted gaze were compared in three different conditions: one with a live interaction, another with a bidirectional video call interaction, and a third condition of merely seeing the other person on a computer screen. Autonomic arousal was measured as skin conductance responses, affective valence was measured with facial EMG, and subjective arousal and valence were measured with a questionnaire. Moreover, the effects of genuine eye contact, eye contact over a video call, and a video presentation of direct gaze on self-referential processing were measured with the LIF. LIF was not completed in response to averted gaze in order to avoid excess repetition of the task. If the physical presence of the other person is necessary for the affective and cognitive effects, only live eye contact, and not eye contact over a video call, will elicit greater autonomic arousal responses and facial reactions associated with positive affect in comparison to averted gaze within the same condition, and self-referential processing will be higher in the live condition than in the other two conditions. If, however, the physical presence of the other person is not required and being seen by them 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 participants watch a mere video presentation of the other person.

In Study III, the effect of genuine eye contact on dishonesty was investigated. This was done by using a computer-assisted lying game that participants played against a confederate of the experimenter, whom they believed to be another participant. On each trial, participants were first briefly presented with a view of the confederate after which they reported to the confederate the color of a circle appearing on the computer screen. Participants were able to gain more points by lying to the confederate. Lying was explicitly allowed in the rules of the game. Depending on the trial, the confederate was gazing either directly at the participants' eyes or downward. In addition, the generalizability of lying in the game to lying in everyday life was examined with a self-report scale of lying in the past 24 hours. Lying in the game was expected to have a positive correlation with reported lying in the past day.

In all studies, subjective self-awareness was also measured with the Situational Self-Awareness Scale (SSAS; Govern & Marsch, 2001). In Studies I and III, subjective public and private self-awareness (awareness of one's inner experience) and awareness of immediate surroundings were measured in response to direct and averted gaze. In Studies I and III, higher public self-awareness was expected in response to direct than averted gaze, though only when the stimuli were presented live (i.e., in Study I, only in Experiment 2). In Study II, the public self-awareness subscale was administered in response to direct gaze in the live, video call, and mere video conditions, and the hypotheses were similar to those mentioned above. In addition, in Study III, the effect of direct gaze on lying was expected to be mediated by heightened public self-awareness by direct gaze.

2 METHODS AND RESULTS

2.1 General methodology

Participants were recruited from email lists of University of Tampere (all studies), Tampere University of Applied Sciences (Study I and III), Tampere University of Technology (Study I), and various upper secondary schools in Tampere (Study I, Experiment 2), and from a local Facebook group (Study II). All experiments had different sets of participants. All participants were native speakers of Finnish with no reported history of neurological or psychiatric disorders and with normal or corrected-to-normal vision. In all studies, participants were rewarded with course credit or a movie ticket. In Study I, participants were able to choose a 10-euro gift card to a retail chain instead of the movie ticket.

All studies were carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) and with protocols reviewed by the Ethics Committee of the Tampere region. Written, informed consent was obtained from all study participants. In all studies, all written and oral instructions that participants received and all questionnaires they completed were in Finnish.

In all studies, the stimuli were faces with direct gaze or gaze averted either downward (Studies I and III) or to the side (Study II). Responses to these stimuli were compared in between-subjects (Study I) and within-subjects (Studies II and III) study designs. In Experiments 1a and 1b of Study I and in the video call and video conditions of Study II, the stimuli were presented on a computer screen. In Experiment 2 of Study I, in the live condition of Study II, and in Study III, live presentations of a model's face served as stimuli. In Experiment 2 of Study I and in all conditions of Study II and Study III, the stimuli (both live and on the screen) were presented through a voltage-sensitive, liquid-crystal shutter window (NSG UMU Products Co. Ltd.) measuring 21.5 cm × 38 cm. The state of the shutter window (transparent or opaque) was operated by a desktop computer and the shutter window switched between states in 3 ms. See Table 1 for details of the stimulus presentations in each study.

Table 1. Details of stimuli used in Studies I, II, and III

	Study I			Study II			Study III
	Exp. 1a	Exp. 1b	Exp. 2				
Presentation mode	Video	Video	Live	Live	Video call	Video	Live
Length	5 s	1 s	5 s	5 s	5 s	5 s	4.4 s
Gaze directions	Direct vs. downward	Direct vs. downward	Direct vs. downward	Direct vs. sideways	Direct vs. sideways	Direct vs. sideways	Direct vs. downward

2.2 Study I

2.2.1 Methods for Experiments 1a and 1b

In Experiments 1a and 1b of Study I, the effect of perceived gaze direction on self-referential processing was investigated by presenting participants with videos of another person. Experiments 1a and 1b differed only in the length of the stimulus presentation (5 s and 1 s, respectively) and in the used tasks (foreign-language task was used in both experiments, but LIF was used only in Experiment 1b).

In Experiment 1a, there were 62 participants (age range = 19–31 years, mean age = 23.9 years, *SD* = 3.2, 33 females, 29 males). In Experiment 1b, there were 40 participants (age range = 19–40 years, mean age = 23.9 years, *SD* = 4.3, 32 females, 8 males). Sensitivity analyses (α = .05) indicated that these samples can detect medium-sized effects (Cohen's $d = 0.5$) with powers of 79 % and 60 %, respectively. The analyses were performed using the power.t.test() function in R (Version 3.6.1).

The stimuli were video clips of a person with either direct gaze or averted (downward) gaze. In Experiment 1a, the stimuli were presented for 5 seconds at a time, and in Experiment 1b, for 1 second at a time. Two males and two females acted as models. They maintained a neutral expression and they sat still as motionless as possible; blinking was allowed. The models were filmed against a dark background. The videos did not contain a soundtrack.

The video clips and the pronoun-selection tasks were presented in full-screen mode on a 19-inch computer screen with a resolution of 1024×768. The participants were seated at 100 cm distance from the computer screen. The face of the model covered a visual angle of approximately 11° horizontally and 15° vertically. For an illustration of the stimuli, see Figure 1.

Figure 1. Still images from the video clips used in Experiments 1a and 1b. From "Genuine eye contact elicits self-referential processing" by J. O. Hietanen and J. K. Hietanen, 2017, *Consciousness and Cognition, 51,* p. 103 (https://doi.org/10.1016/j.concog.2017.01.019). Copyright 2017 by Elsevier Inc.

Participants were randomly assigned to two groups. One group was presented only with videos of direct gaze (direct gaze group) and another presented only with videos of averted gaze (averted gaze group). The genders and identities of the models as well as their gaze directions were counterbalanced across participants' gender. In each experiment session, two to four participants took part at the same time. At least one participant was assigned to a different group than the others. The experiment was conducted on computers in cubicles. Participants wore earmuffs during the experiment.

Upon arrival at the laboratory, participants were informed about the general aspects of the experiment. They were told that that the experiment would be carried out on computers and it includes tasks, which would be later instructed on the computer screen. Participants were seated in the cubicles and a written, informed consent was obtained. They filled in information regarding their age and gender in the computer program. They were informed that the experimenter would be seated behind a partition wall during the experiment and not be able to observe the participants.

The foreign-language task began with detailed instructions on how the task would be carried out (Davis & Brock, 1975). The task consisted of multichoice questions regarding sentences in foreign languages. In each sentence, one pronoun was underlined, and the task was to guess which one of six possible Finnish translations for the target word was correct. Participants were explicitly told that they were not expected to know the answer but to guess the word instead. The six answer options were pronouns in each grammatical person all in the same conjugation form. On each trial, the options were presented in a different, randomized order. The first 10 sentences were in Swahili and the following 10 sentences in Basque. These languages were chosen because it was considered unlikely that participants would understand them. The sentences were extracted from language books (Benjamin et al., 1998; King, 1994; Mohamed, 2001). The task included sentences such as *Nakaa na dada yangu* (I live with my sister) and *Gu fruta saltzen ari gara* (We sell fruits). To strengthen the effect of the other's gaze direction, participants were instructed to imagine that the person in the video were a real person sitting opposite to them; someone they could see, hear, talk to, and touch. The task included 20 trials, each of which consisted of a video of a person and one multichoice task. After each video, a task item and its answer options were presented on the screen. After choosing one of the six answer options, the next trial began immediately.

In Experiment 1b, the foreign-language task was followed by the LIF (Wegner & Giuliano, 1980, 1983). Instructions for the LIF explained that to understand the meaning of a sentence, some words can be redundant, and the intention of the task was to investigate the redundancy of pronouns in sentences. Participants were instructed that the program would present Finnish sentences, each containing a blank, with the task of choosing the one from three pronoun options that they thought would best fit the sentence. The instructions explained that all the options would be grammatically correct, and the task was to choose, and when in doubt, to guess the one that makes most sense to them. On each trial, there were three pronouns to choose from. One option was always first singular, and the two others were either first plural, third singular, or third plural. For each trial, the options were presented in a randomized order. The task included 10 Finnish sentences, most of which were directly translated from the LIF by Wegner and Giuliano (1983). The task included sentences such as *Myyjä yritti taivutella (minua, häntä, meitä) ostamaan sanakirjan* (The salesman tried to persuade [me, her, us] to buy a dictionary). Each of the 10 trials consisted of a video and one multichoice task, and they were presented similarly to the foreign-language task.

Participants then completed the SSAS (Govern & Marsch, 2001) on the computer. The SSAS measures three forms of situational awareness (public self-awareness, private self-awareness, and awareness of immediate surroundings), each of which is measured with three items. The items were modified so that they referred to the moment of watching the stimuli instead of the present moment, and participants were instructed to answer based on how they were feeling at that moment. Public self-awareness was measured with items such as "I was concerned about the way I present myself", private self-awareness with items such as "I was conscious of my inner feelings", and awareness of immediate surroundings with items such as "I was keenly aware of everything in my environment". All items were answered on a 7-point Likert scale, ranging from strong disagreement to strong agreement.

After these tasks, three manipulation check items were presented. The participants were asked whether the person in the video had looked like they were looking directly at the participant and whether the participant had understood the sentences in Swahili or the sentences in Basque. These items were answered on the same 7-point Likert scale.

After all participants had completed the tasks and the questionnaires, the experimenter debriefed the participants, thanked them, and gave them the participation rewards. In total, the experiment lasted less than one hour.

2.2.2 Methods for Experiment 2

Experiment 2 differed from Experiments 1a and 1b in two regards: in Experiment 2, the stimulus was a live person instead of a video, and in Experiment 2, the data were collected from only one participant at a time with no other participants present.

The participants were 42 people (age range = 16–35 years, mean age = 23.7 years, *SD* = 4.2, 35 females, 7 males). A sensitivity analysis (α = .05) performed using R indicated that this sample size is sufficient for detecting medium-sized effects (d = 0.5) with a power of 62 %.

The stimuli were the face of either a male or a female model (i.e., research assistant). Participants were randomly assigned to direct gaze and averted gaze groups and, depending on the group assignment, participants saw the model either making eye contact or gazing 30° downward. The genders of the models and gaze directions were counterbalanced across participants' gender. The model maintained a neutral expression on their face. They did not give any instructions to the participant. The model's face was presented through a liquid-crystal shutter window that was attached to a panel on a table between the participant and the model. A computer screen and a keyboard were placed on the participant's side of the shutter window. The height of the computer screen was adjusted so that the participant was able to see the entire face of the model, but nothing below their chin. Participants were seated at 80 cm from the computer screen and 100 cm from the shutter window. The face of the model was at 30 cm from the shutter window. For illustrations of the arrangement, see Figure 2.

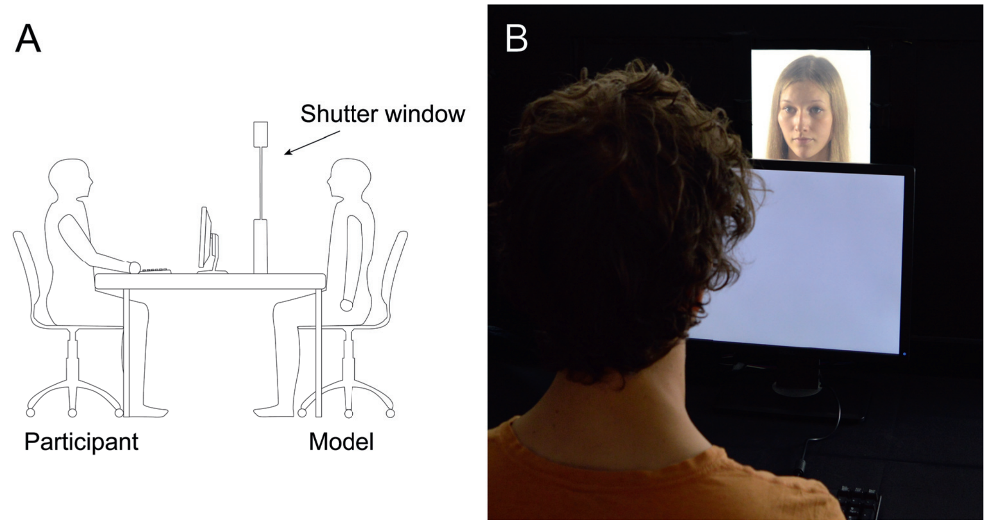

Figure 2. Schematic (A) and photographic (B) illustration of the arrangement in Experiment 2. Figure 2A is adapted from "Psychophysiological responses to eye contact in a live interaction and in video call" by J. O. Hietanen, M .J. Peltola, and J. K. Hietanen, 2020, *Psychophysiology, 57*(6), Article e13587, p. 4 (https://doi.org/10.1111/psyp.13587). CC BY 4.0. Figure 2B is adapted from "Genuine eye contact elicits self-referential processing" by J. O. Hietanen and J. K. Hietanen, 2017, *Consciousness and Cognition, 51,* p. 107 (https://doi.org/10.1016/j.concog.2017.01.019). Copyright 2017 by Elsevier Inc.

After arriving at the laboratory, the participant was told that that the experiment would be carried out on a computer and that it includes tasks regarding linguistic perception, which would be later instructed on the computer screen. The participant was seated in front of the computer and the shutter window, and a written, informed consent was obtained. The experimenter demonstrated the participant the functioning of the shutter window and explained that the model would be sitting behind the shutter window and the shutter window would become transparent on each task trial. The participant was informed that the experimenter would be in the next room during the experiment and not observing the participant.

Before beginning the tasks, participants filled in information regarding their age and gender in the computer program. Then, the program presented the participant with instructions of the foreign-language task (Davis & Brock, 1975). Each trial consisted of the shutter window becoming transparent for 5 s and one multichoice task. When the shutter window switched back to opaque, the task was immediately presented on the computer screen in front of the shutter window. After choosing one of the six answer options, there was an interstimulus interval (ISI) of 1 s before the next trial. The foreign-language task consisted of 20 trials. After that, the LIF followed, beginning with instructions for the task (Wegner & Giuliano, 1980, 1983). The LIF task trials were presented similarly to the foreign-language task. The LIF consisted of 10 trials. After these two tasks, the participant completed the SSAS (Govern & Marsch, 2001) and the manipulation check items. Then, the experimenter returned to the laboratory, debriefed and thanked the participant and gave them the participation reward. The experiment lasted less than one hour.

2.2.3 Results

In all three Experiments, all participants correctly perceived whether the person they had seen was looking at them or away from them. On a scale ranging from 1 (strongly disagree) to 7 (strongly agree), most of the participants in the direct gaze group strongly agreed (M_{Exp1a} = 6.45, SD_{Exp1a} = 0.72; M_{Exp1b} = 5.10, SD_{Exp1b} = 1.92; M_{Exp2} = 6.67; SD_{Exp2} = 0.66) with the statement that the person had appeared to be looking at them, whereas most of the participants in the averted gaze group strongly disagreed with it (M_{Exp1a} = 1.26, SD_{Exp1a} = 0.77; M_{Exp1b} = 1.75, SD_{Exp1b} = 1.07; M_{Exp2} = 1.24; SD_{Exp2} = 0.62); in between-group comparisons within experiments, all *p*s < .001. Participants reported that they had not understood the foreign languages in the foreign-language task. In Experiments 1a, 1b, and 2, the mean scores for the statement "I understood the sentences in Swahili" were 1.05 (SD = 0.28), 1.13 (*SD* = 0.40), and 1.40 (*SD* = 1.27), and for the statement "I understood the sentences in Basque", 1.05 (SD = 0.22), 1.05 (*SD* = 0.32), and 1.21 (*SD* = 0.95), respectively. In Experiment 1b, two participants (one in each group) were excluded from the analysis because they reported guessing what the linguistic tasks were about.

Self-referential processing was measured as the number of first-person singular pronoun responses in the two pronoun-selection tasks. In Experiment 1a, the direct gaze group gave a similar number of first-person responses as the averted gaze group in the foreign-language task, $t(60) = -1.30$, $p = .197$, $d = -0.33$, 95% confidence interval (CI) [-0.83, 0.17]. The nonsignificant result was further explored with the Two One-Sided Test (TOST) procedure with equivalence bounds set at $d = \pm\ 0.30$ (Lakens, 2017). The observed effect size (d = -0.33) was significantly within the upper bound of $d = 0.30$, $t(60) = -2.49$, $p = .008$, but not within the lower bound of $d = -0.30$, $t(60) = -0.13$, $p = .550$. This allows the conclusion that, contrary to what was expected, participants in the direct gaze group did not use meaningfully more first-person pronouns than those in the averted gaze group, although they may have used less. Likewise, in Experiment 1b, there were no statistically significant differences in the amount of first-person responses between the two groups in the foreign-language task, $t(36) = -1.62$, $p = .114$, $d = -0.53$, 95% CI [-1.17, 0.13], or in the LIF, $t(36) = -0.85$, $p = .399$, $d = -0.28$, 95% CI [-0.91, 0.36]. Moreover, in the foreign-language task and the LIF, respectively, TOSTs with equivalence bounds of $d = \pm 0.30$ indicated that the effect sizes ($d = -0.53$, $d = -0.28$) were significantly within the upper bound, $t(36) = -2.55$, $p = .008$; $t(36) = -1.78$, $p = .041$, but not within the lower bound, $t(36) = -0.70$, $p = .756$; $t(36) = 0.07$, $p = .474$, providing further evidence that there was no meaningful increase in first-person pronoun use in response to the video presentation of direct in comparison to averted gaze. See Tables 2 and 3 for direct and averted gaze groups' responses on the foreign-language task and the LIF in each experiment.

Because Experiments 1a and 1b both included the foreign-language task, the data on this task was combined to achieve a better statistical power for comparisons. Contrary to what was hypothesized, in the combined data, participants' use of first-person pronouns was significantly lower in the direct gaze groups ($M = 1.64$, $SD = 1.12$) than in the averted gaze groups ($M = 2.12$, $SD = 1.27$), $t(98) = -2.00$, $p = .048$, $d = -0.40$, 95% CI [-0.80, 0.00]. Comparisons between the two groups' responses in other grammatical persons were not significant, all ps > .10.

In Experiment 2, by contrast, the use of first-person singular responses was marginally higher in the direct gaze group than the averted gaze group in the foreign-language task, $t(40) = 1.98$, $p =.055$, $d = 0.61$, 95% CI [-0.01, 1.23], and significantly higher in the LIF, $t(40) = 2.51$, $p = .016$, $d = 0.78$, 95% [0.14, 1.40]. Interestingly, the direct gaze group also gave significantly less responses in the third-person singular form than the averted gaze group in the foreign-language task, $t(40) = -2.08$, $p =.044$, $d = -0.64$, 95% CI [-1.26, -0.02], and a similar, marginal difference was found in the LIF, $t(40) = -1.89$, $p = .065$, $d = -0.58$, 95% CI [-1.20, 0.04] (see Tables 2 and 3).

Subjective self-awareness was measured with the SSAS. There were no significant differences between the direct gaze and averted gaze groups in their ratings of public or private self-awareness in any of the three experiments, all ps > .10. For public self-awareness, a TOST indicated that the observed effect size was not significantly within the equivalent bounds of $d = \pm 0.30$ in Experiment 1a, $t(60) = 0.88$, $p = .190$, in Experiment 1b, $t(36) = -0.92$, = .181, or in Experiment 2, $t(40) = 0.53$, $p = .702$.

However, for the combined data of Experiments 1a and 1b, a TOST indicated that the public self-awareness ratings were not meaningfully higher in the direct gaze than in the averted gaze group, $t(98) = -1.73$, $p = .044$, but they may have been lower, $t(98) = 1.27$, $p = .103$. Unexpectedly, in Experiment 2, participants in the direct gaze group reported significantly lower levels of awareness of immediate surroundings than participants in the averted gaze group, $t(40) = -3.07$, $p = .004$, $d = -0.95$, 95 % CI [-1.58, -0.30]. See Table 4 for responses to the SSAS in each experiment.

Table 2. Comparison of direct and averted gaze groups' responses in each grammatical person in the foreign-language task in Study I.

	Experiment 1a 5 s video stimulus								Experiment 1b 1 s video stimulus								Experiment 2 5 s live stimulus							
	Direct		Averted		*t*(60)	*p*	*d*	95% CI	Direct		Averted		*t*(36)	*p*	*d*	95% CI	Direct		Averted		*t*(40)	*p*	*d*	95% CI
Pronoun	*M*	*SD*	*M*	*SD*					*M*	*SD*	*M*	*SD*					*M*	*SD*	*M*	*SD*				
I	1.74	1.29	2.16	1.24	-1.30	.197	-0.33	[-0.83, 0.17]	1.47	0.77	2.05	1.35	-1.62	.114	-0.53	[-1.17, 0.13]	2.62	1.63	1.81	0.93	1.98	.055	0.61	[-0.01, 1.23]
You	4.45	1.50	4.39	1.54	0.17	.868	0.04	[-0.46, 0.54]	4.63	1.83	3.68	1.70	1.65	.107	0.54	[-0.12, 1.18]	3.86	1.68	4.00	1.92	-0.26	.799	-0.08	[-0.68, 0.53]
He/she	3.16	2.02	3.19	1.99	-0.06	.950	-0.02	[-0.51, 0.48]	3.32	1.63	4.26	1.76	-1.72	.094	-0.56	[-1.20, 0.09]	2.57	1.43	3.52	1.54	-2.08	.044	-0.64	[-1.26, -0.02]
We	2.90	1.25	2.68	1.54	0.64	.528	0.16	[-0.34, 0.66]	3.00	1.41	2.74	1.76	0.51	.614	0.16	[-0.47, 0.80]	3.76	1.76	3.43	2.06	0.56	.576	0.17	[-0.43, 0.78]
You (plural)	4.39	1.96	4.16	2.25	0.42	.675	0.11	[-0.39, 0.60]	4.21	1.27	4.00	2.08	0.38	.709	0.12	[-0,52, 0.76]	3.95	2.18	4.33	2.03	-0.59	.561	-0.18	[-0.79, 0.43]
They	3.35	1.58	3.42	1.95	-0.14	.887	-0.04	[-0.53, 0.46]	3.37	1.54	3.26	1.76	0.20	.845	0.06	[-0.57, 0.70]	3.24	1.34	2.90	1.48	0.77	.448	0.24	[-0.37, 0.84]

Table 3. Comparison of direct and averted gaze groups' responses in each grammatical person in the LIF in Experiments 1b and 2.

	Experiment 1b 1 s video stimulus								Experiment 2 5 s live stimulus							
	Direct		Averted		*t*(36)	*p*	*d*	95% CI	Direct		Averted		*t*(40)	*p*	*d*	95% CI
Pronoun	*M*	*SD*	*M*	*SD*					*M*	*SD*	*M*	*SD*				
I	4.21	1.18	4.58	1.46	-0.85	.399	-0.28	[-0.91, 0.36]	4.48	1.29	3.57	1.03	2.51	.016	0.78	[0.14, 1.40]
He/she	2.00	1.29	1.58	1.39	0.97	.339	0.31	[-0.33, 0.95]	1.81	0.98	2.38	0.97	-1.89	.065	-0.58	[-1.20, 0.04]
We	2.47	0.96	2.84	0.83	-1.26	.216	-0.41	[-1.05, 0.24]	2.86	0.91	2.86	1.31	0.00	1.00	0.00	[-0.60, 0.60]
They	1.32	0.75	1.00	0.82	1.24	.222	0.40	[-0.24, 1.04]	0.86	0.65	1.19	0.93	-1.34	.186	-0.41	[-1.02, 0.20]

Table 4. Comparison of direct and averted gaze groups' responses to the SSAS in Experiments 1a, 1b, and 2.

	Experiment 1a 5 s video stimulus								Experiment 1b 1 s video stimulus								Experiment 2 5 s live stimulus							
	Direct		Averted		*t*(60)	*p*	*d*	95% CI	Direct		Averted		*t*(36)	*p*	*d*	95% CI	Direct		Averted		*t*(40)	*p*	*d*	95% CI
Subscale	*M*	*SD*	*M*	*SD*					*M*	*SD*	*M*	*SD*					*M*	*SD*	*M*	*SD*				
Public	2.34	1.14	2.44	1.48	-0.29	.774	-0.07	[-0.57, 0.43]	2.58	1.34	2.58	1.37	0.00	1.00	0.00	[-0.64, 0.64]	3.38	1.74	2.65	1.38	1.51	.140	0.46	[-0.15, 1.07]
Private	4.01	1.27	3.69	1.14	1.05	.296	0.27	[-0.23, 0.77]	3.81	1.07	3.91	1.26	-0.28	.783	-0.09	[-0.73, 0.55]	3.62	1.01	4.05	1.03	-1.36	.182	-0.42	[-1.03, 0.20]
Surroundings	2.86	1.30	3.17	1.43	-0.90	.374	-0.23	[-0.73, 0.27]	3.44	1.11	3.26	1.28	0.45	.655	0.15	[-0.49, 0.78]	3.02	1.06	4.11	1.25	-3.07	.004	-0.95	[-1.58, 0.30]

2.3 Study II

2.3.1 Methods

In Study II, the participants were 32 people (age range = 20–42 years, mean age = 27.8 years, *SD* = 5.3, 16 females, 16 males). Sensitivity analysis (α = .05, df_n = 2, df_{dn} = 62, estimated correlation = .50, ε = 1.00) indicated that, with this sample size, a 2 × 3 analysis of variance (ANOVA) can detect medium interactions (η^2 = .05) between factors with a power of 80 %. The analysis was conducted using G*Power (Version 3.1.9.6) and with GPower 3.0 effect size specification (Faul et al., 2007).

The experiment consisted of three conditions: a live interaction, a bidirectional video call on a computer, and watching a video presentation of the model on a computer screen without bidirectional view. In all conditions, the stimulus was the face of a model of the same sex as the participant presented against a black background. The models maintained a neutral expression and stayed as motionless as possible. Depending on the trial, they directed their gaze either straight ahead or approximately 30° to either side. In all conditions, the stimuli (a live face or the same face on a computer screen) were presented through a liquid-crystal shutter window, the same device used in Experiment 2 of Study I, attached to a black panel. Participants were seated at 80 cm from the shutter window. A computer screen and a keyboard for responding to questionnaires were placed on participants' side of the window. See Figure 3 for an illustration of participants' view.

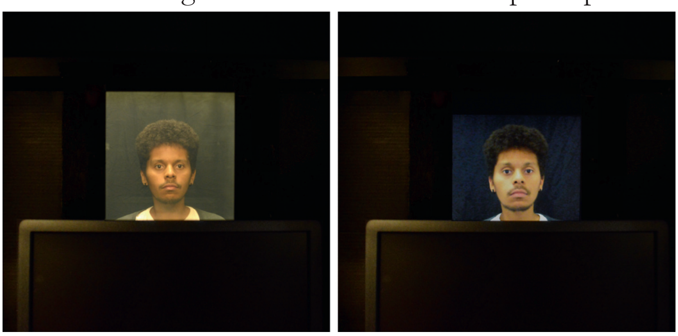

Figure 3. Participants' view of direct gaze in the live (left) and video call (right) conditions. In the video call and mere video conditions, the view on the computer screen was identical. From "Psychophysiological responses to eye contact in a live interaction and in video call" by J. O. Hietanen, M .J. Peltola, and J. K. Hietanen, 2020, *Psychophysiology, 57*(6), Article e13587, p. 3 (https://doi.org/10.1111/psyp.13587). CC BY 4.0.

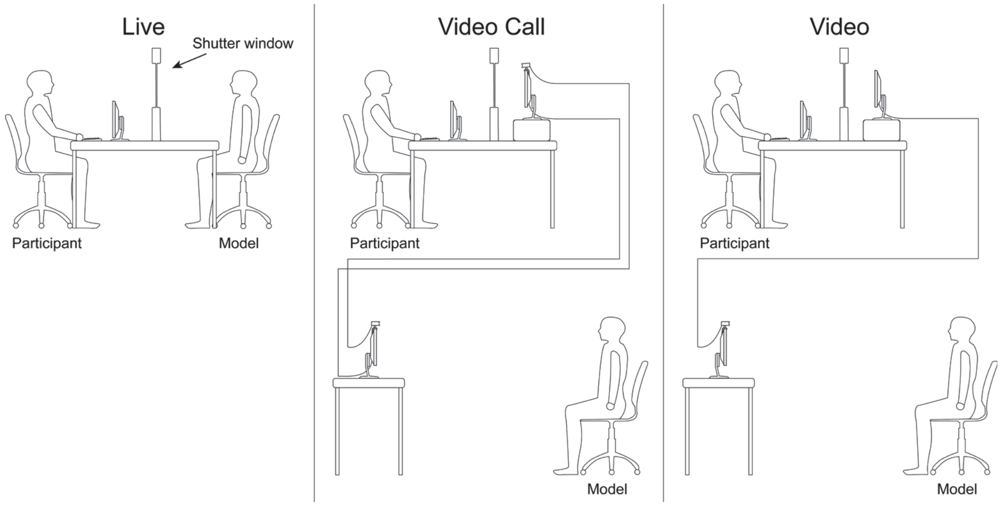

Figure 4. Illustration of the arrangement in each condition. In the video call and video conditions, the model was in another room and their image was transmitted with a zoomed-in web camera. From "Psychophysiological responses to eye contact in a live interaction and in video call" by J. O. Hietanen, M .J. Peltola, and J. K. Hietanen, 2020, *Psychophysiology, 57*(6), Article e13587, p. 4 (https://doi.org/10.1111/psyp.13587). CC BY 4.0.

In the live condition, the model's face was on the other side of the shutter window at 60 cm from it. In the video call and video conditions, the model's face was presented on a 19-inch computer screen at 28 cm behind the shutter window. During these conditions, the model was in another room and a web camera transmitted the model's image in real time to the participants' screen. See Figure 4 for an illustration of the setup in the three conditions. In all conditions, participant's view of the size and location of the stimuli was controlled. The face of the model covered a visual angle of approximately 7° horizontally. During direct gaze stimulus presentations, the model was always looking either directly in the eye region of the participant (live condition) or into the camera (video call and video conditions). Great care was taken to ensure that the stimuli were visually comparable in the three conditions.

In the beginning of each condition, the model's seat was adjusted so that their face was directly in front of the participant vertically and horizontally. In the video call and video conditions, the web camera and computer screen on the model's side were far enough from the model so that it appeared as if they were looking directly into the camera even though, during seat adjustment, they were looking at the screen beneath it. In the beginning of the video condition, the web camera on participant's side was on top of the screen, and after seat adjustment, it was visibly removed. After seat adjustment, the shutter window turned back to opaque.

In the beginning of the experiment, the participant was informed that physiological measurements and questionnaire data would be collected during a simple interaction situation. A written, informed consent was obtained. The model was already present in the laboratory, but they did not give any instructions to the participant. The measurement sensors were then attached to the participant's left hand and face.

The physiological measurements included skin conductance responses (SCR) and facial electromyographic activity (EMG). The physiological measurements were recorded using a BrainVision QuickAmp amplifier and BrainVision Recorder software (Brain Products GmbH, Munich, Germany) at a sampling rate of 1000 Hz. EEG was also measured to investigate research questions not related to this dissertation.

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. 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. This time frame 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 et al., 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 gaze direction and condition, mean SCR magnitude was calculated by averaging the data from all accepted trials including those with zero responses (mean number of accepted trials of a total of 16 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.

Facial EMG was measured over the zygomaticus major and corrugator supercilii muscle regions. The skin over the recording sites was cleaned and slightly abraded with alcohol. To conceal the purpose of the facial sensors, the experimenter told participants that the sensors were used to measure skin temperature. 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 before stimulus onset (baseline) to 5000 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 gaze direction and condition (mean number of accepted trials in each condition: $M_{\text{live}} = 14.8$, $M_{\text{videocall}} = 15.1$, $M_{\text{video}} = 14.8$). These standardized change scores were used in the statistical analyses.

The three conditions were presented in a counterbalanced order. Each condition began with 16 trials of stimulus presentation for 5 seconds at a time during which the physiological responses were measured. On 8 trials, the model directed their gaze straight ahead (direct gaze), and on 8 trials, to either side (averted gaze, 4 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 ISI of at least 14.5 seconds 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 the LIF to measure self-referential processing and the public scale of the SSAS to measure subjective public self-awareness. These tasks were instructed similarly as in Study I. The LIF included 10 items, and, in contrast to how LIF was administered in Study I, only five of the items were completed with personal pronouns. The five other items were completed with adjectives. These sham items were included to conceal the actual purpose of the task. The LIF items were different in each condition, and the order of the LIF items was pseudorandomized. The SSAS subscale included 3 items. To avoid excess repetition of the LIF and SSAS, these tasks were only administered once per each condition, in response to the direct gaze stimulus. On both tasks, each task item was preceded with a 5-second presentation of the stimulus.

Subjective valence and arousal were measured with the Self-Assessment Manikin (SAM; 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 with the task of evaluating their level of arousal and valence during the presentations. They were informed about the meaning of arousal and valence and about the used scale. They were then presented with either direct or averted gaze for 5 seconds and asked to evaluate their subjective feelings on these two dimensions on a 9-point scale (1 = calm/unpleasant, 9 = arousing/pleasant). After that, they were 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 administered a questionnaire unrelated to this dissertation, debriefed, thanked, and given the participation rewards. The experiment lasted approximately 1,5 hours.

2.3.2 Results

SCRs were analyzed with a 3 × 2 (Condition × Gaze Direction) within-subjects analysis of variance (ANOVA). A statistically significant main effect was found for gaze direction, $F(1, 31) = 4.73$, $p = .037$, $\eta_p^2 = .13$, 90% CI [.00, .31]. The SCRs were greater in response to direct gaze ($M = 0.034$ µS, $SD = 0.045$) than to averted gaze ($M = 0.021$ µS, $SD = 0.027$). The main effect of condition, $F(2, 62) = 0.93$, $p = .399$, $\eta_p^2 = .03$, 90% CI [.00, .10], was not significant. Importantly, there was a significant interaction between condition and gaze direction, $F(2, 62) = 4.49$, $p = .015$, $\eta_p^2 = .13$, 90% CI [.01, .24]. Paired *t* tests showed that the SCRs were significantly greater in response to direct gaze than to averted gaze in the live condition, $t(31) = 2.57$, $p = .015$, $d = 0.45$, 95% CI [0.09, 0.82], and in the video call condition, $t(31) = 2.15$, $p = .040$, $d = 0.38$, 95% CI [0.02, 0.74], but not in the mere video condition, $t(31) = -0.69$, $p = .494$, $d = -0.12$, 95% CI [-0.47, 0.23]. A TOST indicated that the observed effect size ($d = -0.12$) in the mere video condition was significantly within the upper equivalence 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, it can be concluded that, in the mere video condition, the perception of direct gaze did not elicit meaningfully greater SCRs than the perception of averted gaze, though it may have elicited smaller responses. See Figure 5 for SCRs in response to direct and averted gaze within each condition.

In order to compare the magnitude of SCR increase by direct gaze in the live and video call conditions, differential responses were calculated by subtracting the SCRs in response to averted gaze from those to direct gaze within these conditions. A paired *t* test indicated no significant difference in the magnitude of SCR increase by direct gaze between the live and video call conditions, $t(31) = 1.16$, $p = .255$, $d = 0.21$, 95% CI [-0.15, 0.55]. However, a TOST procedure with equivalence bounds of $d = \pm0.30$ did not support the absence of a meaningful difference between the conditions, $t(31) = 0.54$, $p = .298$. Therefore, the data does not allow the conclusion that the magnitude of SCR increase in the two conditions was statistically equivalent.

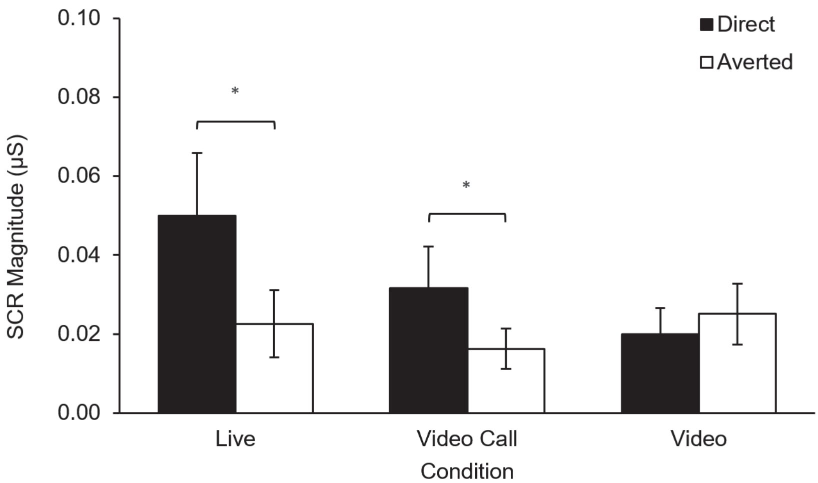

Figure 5. SCR magnitudes and standard errors of the mean (SEM) in response to direct and averted gaze within each condition.
* *p* < .05
From "Psychophysiological responses to eye contact in a live interaction and in video call" by J. O. Hietanen, M .J. Peltola, and J. K. Hietanen, 2020, *Psychophysiology, 57*(6), Article e13587, p. 6 (https://doi.org/10.1111/psyp.13587). CC BY 4.0.

Zygomaticus EMG responses were analyzed with a 3 × 2 × 10 (Condition × Gaze Direction × Time) within-subjects ANOVA. Statistically significant main effects were found for gaze direction, $F(1, 30) = 18.34$, $p < .001$, $\eta_p^2 = .38$, 90% CI [.15, .54], and time, $F(3.99, 119.73) = 4.73$, $p = .001$, $\eta_p^2 = .14$, 90% CI [.04, .21] (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 ($M = 0.54$, $SD = 0.56$) than to averted gaze ($M = 0.21$, $SD = 0.40$), and the zygomatic activity increased as a function of time. Contrary to what was expected, the interaction between condition and gaze direction was not significant, $F(2, 60) = 0.30$, $p = .739$, $\eta_p^2 = .01$, 90% CI [.00, .06]. Other interactions were also not significant (all ps > .10).

Corrugator EMG responses were similarly analyzed with a 3 × 2 × 10 within-subjects ANOVA. The main effect of gaze direction was significant, $F(1, 30) = 8.00$, $p = .008$, $\eta_p^2 = .21$, 90% CI [.03, .39]. Corrugator responses were smaller to direct gaze ($M = -0.10$, $SD = 0.71$) than to averted gaze ($M = 0.15$, $SD = 0.48$). The main effects of condition, $F(2, 60) = 1.15$, $p = .324$, $\eta_p^2 = .04$, 90% CI [.00 .12], and time, $F(1.76, 52.69) = 1.22$, $p = .300$, $\eta_p^2 = .04$, 90% CI [.00, .13] (Greenhouse-Geisser corrected, $\varepsilon = 0.20$), were not significant. There was a significant two-way interaction between gaze direction and time, $F(2.90, 87.03) = 4.08$, $p = .010$, $\eta_p^2 = .12$, 90% CI [.02, .21] (Greenhouse-Geisser corrected, $\varepsilon = 0.32$). The effect of time did not reach statistical significance in the direct gaze trials, $F(1.73, 51.79) = 2.27$, $p = .120$, $\eta_p^2 = .07$, 90% CI [.00, .18] (Greenhouse-Geisser corrected, $\varepsilon = 0.19$), or in the averted gaze trials, $F(3.36, 100.85) = 2.12$, $p = .096$, $\eta_p^2 = .07$, 90% CI [.00, .13] (Greenhouse-Geisser corrected, $\varepsilon = 0.37$). A marginal two-way interaction was found between condition and gaze direction, $F(2, 60) = 3.05$, $p = .055$, $\eta_p^2 = .09$, 90% CI [.00, .20]. Although the interaction was not significant, it was further examined with paired *t* tests. They indicated significantly lower responses to direct vs. averted gaze in the live condition, $t(30) = -3.09$, $p = .004$, $d = -0.55$, 95% CI [-0.93, -0.17], and in the mere video condition, $t(30) = -2.59$, $p = .015$, $d = -0.47$, 95% CI [-0.83, -0.09], but not in the video call condition, $t(30) = -1.06$, $p = .299$, $d = -0.19$, 95% CI [-0.54, 0.17]. In the video call condition, a TOST with equivalence bounds of $d = \pm 0.30$ did not support the absence of a meaningful effect, $t(30) = -0.62$, $p = .270$. No other significant interaction effects were found (all *p*s > .10). See Figure 6 for the EMG responses to direct and averted gaze within each condition.

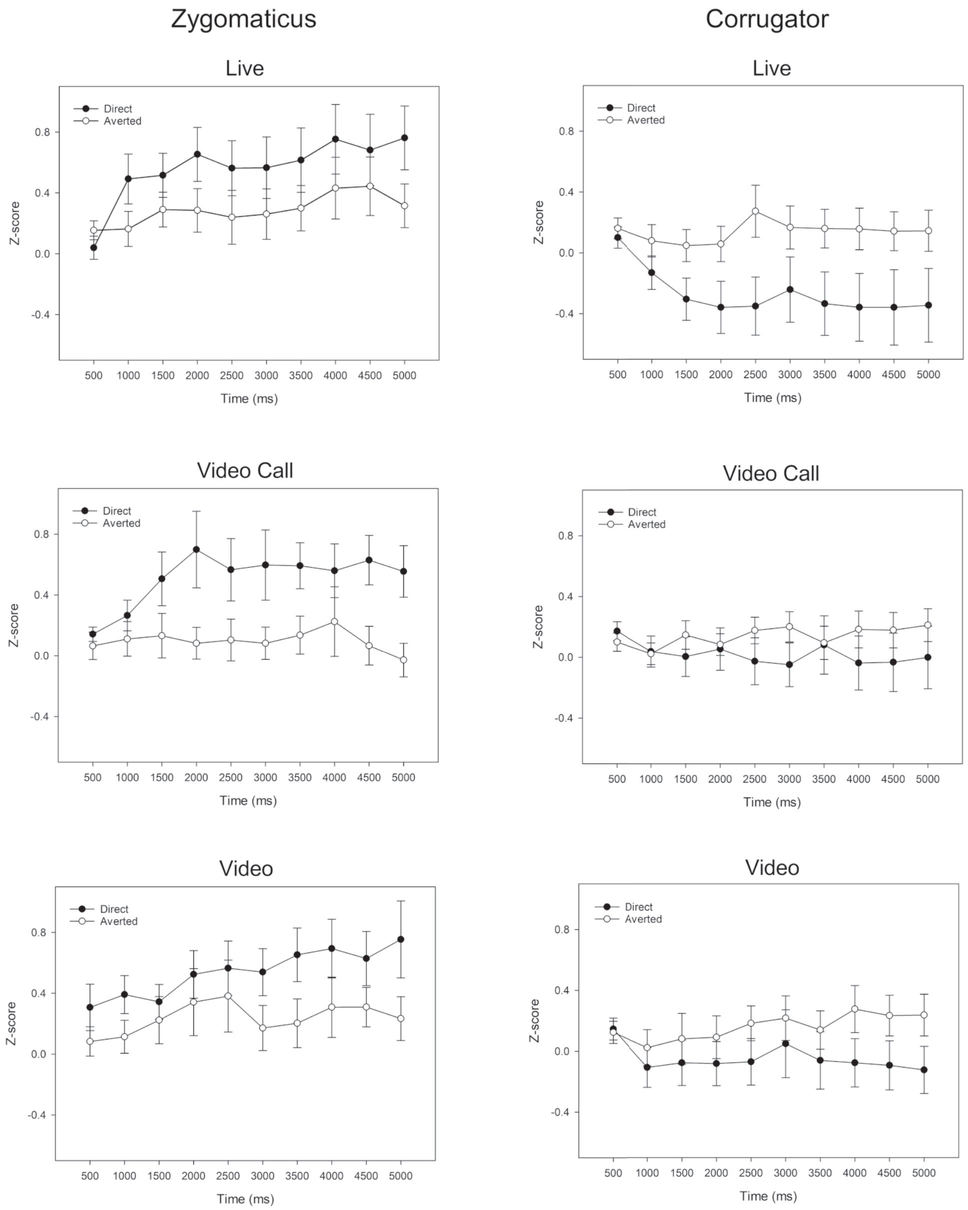

Figure 6. Standardized mean zygomatic and corrugator EMG responses (and SEM) in response to direct and averted gaze within each condition.
From “Psychophysiological responses to eye contact in a live interaction and in video call” by J. O. Hietanen, M .J. Peltola, and J. K. Hietanen, 2020, *Psychophysiology, 57*(6), Article e13587, p. 8 (https://doi.org/10.1111/psyp.13587). CC BY 4.0.

In the LIF, a within-subjects one-way ANOVA indicated no statistically significant difference in participants' use of first-person pronouns between the three conditions, $F(2, 62) = 1.37$, $p = .261$, $\eta_p^2 = 0.04$, 90% CI [.00, .13] (see Table 5). A marginally significant difference was found in the use of third-person pronouns, $F(2, 62) = 2.62$, $p = .081$, $\eta_p^2 = 0.08$, 90% CI [.00, .18]. Although this difference was not significant, pairwise comparisons (LSD test) were conducted. Third-person pronoun use in the live condition was found to be lower than in the video condition, $p = .024$. Pairwise comparisons between the video call condition and the other two conditions were not significant (both ps > .10).

Table 5. Comparison of responses in each grammatical person between conditions

	Live		Video Call		Video		$F(2, 62)$	p	η_p^2	90% CI
Pronoun	*M*	*SD*	*M*	*SD*	*M*	*SD*				
I	2.78	1.13	2.50	1.11	2.44	1.16	1.37	.261	0.04	[.00, .13]
You	0.09	0.30	0.03	0.18	0.03	0.18	1.00[a]	.374	0.03	[.00, .13]
He/she	0.88	0.94	1.13	0.87	1.38	1.01	2.62	.081	0.08	[.00, .18]
We	1.00	0.95	1.25	0.88	0.91	0.78	1.88	.161	0.06	[.00, .15]
They	0.50	0.57	0.34	0.48	0.47	0.51	0.69	.504	0.02	[.00, .09]

[a] Greenhouse-Geisser corrected $F(1.59, 49.57)$, $\varepsilon = 0.80$.

In the public self-awareness scale of Situational Self-Awareness Scale, a within-subjects ANOVA indicated no significant difference between the three conditions, $F(2, 62) = 0.36$, $p = .699$, $\eta_p^2 = 0.01$, 90% CI [.00, .06], ($M_{live} = 2.79$, $SD_{live} = 1.46$; $M_{videocall} = 2.87$, $SD_{videocall} = 1.35$; $M_{video} = 2.76$, $SD_{video} = 1.49$).

Subjective valence and arousal were measured with the SAM in response to both gaze directions in the three conditions (see Table 6). 3 × 2 within-subjects ANOVAs found no significant main effects or interaction effects for either scale (all ps > .10).

Table 6. Mean SAM scores by gaze direction and condition

	Live				Video Call				Video			
	Direct		Averted		Direct		Averted		Direct		Averted	
	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. Adapted from "Psychophysiological responses to eye contact in a live interaction and in video call" by J. O. Hietanen, M .J. Peltola, and J. K. Hietanen, 2020, *Psychophysiology, 57*(6), Article e13587, p. 9 (https://doi.org/10.1111/psyp.13587). CC BY 4.0.

2.4 Study III

2.4.1 Methods

Participants were 51 people (age range 19–37 years, mean age = 24.7 years, *SD* = 4.1, 26 females, 25 males). A sensitivity analysis (α = .05) performed using R indicated that this sample size is sufficient for detecting medium-sized effects (*d* = 0.5) with a power of 94 %. In recruitment, participants were told that they would be rewarded with a movie ticket or course credit, but if they win the game, they would be given another movie ticket. However, as the opponent in the game was a confederate of the experimenter, every participant was rewarded with the extra movie ticket.

When a participant arrived in the laboratory, a confederate of the same sex also came in. Participants were led to believe that the confederate was another participant. A male experimenter welcomed the two and told them that the experiment would be carried out on computers on which an interactive game would be played. He told that the study investigates physiological reactions and for that reason two electrodes were to be attached to the fingers of one player at a time. A written, informed consent was obtained from the participant and, as a sham, from the confederate.

After flipping a coin, the experimenter named the participant as player number one and the confederate as player number two and guided them to seats on the opposite sides of a liquid-crystal shutter window. The shutter window was the same device used in Study II and in Experiment 2 of Study I, and it was similarly attached to a black panel on a black table (see Figure 2A). The participant and the confederate both had a 19-inch computer screen and a keyboard on the table in front of them. The heights of the computer screens were such that the players were easily able to see each other over the screens when the window was transparent. The participant was seated at 70 cm from the computer screen and 80 cm from the shutter window. The face of the confederate was at 70 cm from the shutter window and 150 cm from the participant. The experimenter demonstrated how the shutter window worked by making it transparent for a moment. Participant's and confederate's seat heights were adjusted so that they had their eyes on the same level.

The experimenter said that, in the game, player one (i.e., the participant) would be collecting points first and the physiological measurements would be taken first from player one. He then attached two electrodes coated with isotonic paste to the palmar surface of the medial phalanges of the index and middle fingers on the participant's left hand for sham skin conductance measurements. The purpose of the measurements was to draw participants' attention away from the actual research question, and thus the data were not analyzed.

Before the game started, the players were both shown an instructional video that explained and demonstrated the scoring rules of the game. On each trial, participants were presented with a red or a blue circle and asked to report its color to the confederate by pressing left arrow (for red) or right arrow (for blue) on the keyboard. The confederate's response to the reported color (whether they wanted to check what the color had actually been) was then shown as a text "Player #2 checks" or "Player #2 does not check" on the screen. Participants gained 1 point by reporting the color to be red, no points by reporting blue, and lost 5 points if caught lying. The confederate lost 3 points if they checked a color that the participant had reported honestly. Lying was explicitly allowed in the instructions. The experimenter verified that the players had understood the rules. He then said that during the game he would be seated behind a curtain and not be able to observe the participants, after which he left, and the game started.

In the beginning of each trial of the game, the shutter window turned transparent and the confederate's face was presented against a black background for 4400 milliseconds. The confederate maintained a neutral facial expression. In half of the trials, the confederate was gazing at the participant's eyes (direct gaze), and in the other half, 20° downward with a slight tilt of the head toward the computer screen on their side of the panel (averted gaze). To appear natural, on the direct gaze trials, the confederate raised their gaze from the computer screen toward the participant shortly after the shutter window had turned transparent (in less than one second). The direct and averted gaze trials were presented in a pseudorandomized order.

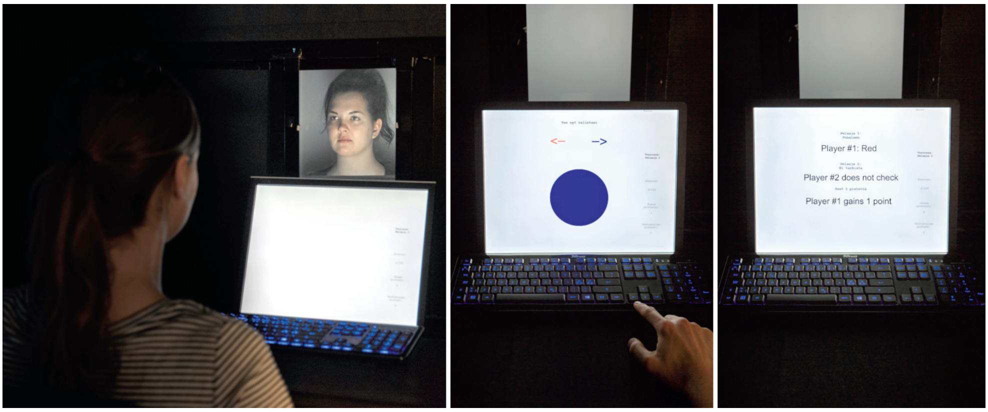

Figure 7. An example of a trial sequence in Study III. The participant first saw the opponent through the shutter window. Then, the window turned opaque and the participant was presented with a red or a blue circle. The participant decided which color to report to the opponent, who then decided whether they believed it. Finally, the scores were updated. From "Eye contact reduces lying" by J. O. Hietanen, A. H. Syrjämäki, P. K. Zilliacus, and J. K. Hietanen, 2018, *Consciousness and Cognition, 66,* p. 68 (https://doi.org/10.1016/j.concog.2018.10.006). Copyright 2018 by Elsevier Inc.

The lying game was adapted from a study by Karton and others (2014) and run on E-Prime (Version 2.0). It was presented on the computer screen in front of the participant. Each trial started with the presentation of a view of the confederate through the shutter window for 4400 milliseconds. After 2400 milliseconds from the onset of the face stimulus, a two-second animation was simultaneously presented on the computer screen. In the animation, pictures of a red and a blue circle alternated rapidly. Then the window turned opaque, the animation stopped, and the participant was shown either a red or a blue circle on the screen. They then reported the color to the confederate, who responded by either checking the color or accepting the report. The confederate's moves had been written into the computer program, but the participants were led to believe that the confederate made the moves in the game independently. The game consisted of 120 trials, 60 with each color. The points of the players and the trial number were presented on the right side of the screen. See Figure 7 for an example of a trial sequence.

Participants' reports of the colors were checked 12 times (6 times after each gaze direction), but only when they had reported the color honestly. Participants were checked an equal number of times after each gaze direction to avoid biasing them into thinking that the risk of being caught were higher in either situation. They were not caught lying even once because this was the only way to catch them lying for the same number of times on the direct and averted gaze trials. Moreover, being caught was presumed to increase the probability of participants restraining from lying altogether, which would have been antithetical to the aim of the study.

After playing 120 trials, the game ended, and questionnaires followed. Participants were led to believe that after the questionnaires the roles in the game would switch and it would be the confederate's turn to collect points. However, the confederate's turn to collect points was not played, as it was insignificant for the research question.

Participants were presented with a control question: "How often do you estimate the opponent was looking at you when the window opened, and you saw the opponent?" The question was answered with a number ranging from 0 to 100 percent. The aim of this question was to exclude participants who had not noticed variation in the gaze direction of the confederate (due to, for example, avoiding looking at them altogether), thus responding 0 or 100 percent.

Participants then completed the SSAS in response to both gaze directions. The shutter window was opened two additional times, and participants filled in the questionnaire after each view of the confederate. They were informed that the shutter window would soon open and after that they would be asked how they were feeling when they were looking at the other person. They were then shown the nine questionnaire items to familiarize with them first. A text "The window will open as soon as Player #2 has read their instructions and pressed a button. Please wait." was presented, after which the window turned transparent for four seconds and participants saw the confederate either looking at them or downward. Participants then completed the questionnaire. After this, they read the same instructions again, saw the confederate now looking at the other direction and then completed the questionnaire regarding that situation. The order of the gaze directions was counterbalanced.

After the SSAS, participants completed the Lying Frequency Questionnaire (LFQ; Serota et al., 2010). In the instructions, participants were asked to think back to where they were and what they were doing during the past 24 hours and to count how many times they had lied in that time, including all lies, big and small. They were then asked separately about lies to family members, friends, business contacts, acquaintances, and total strangers. For each type of recipient, they were asked separately about lies in face-to-face and mediated situations (by phone or in a written message).

Finally, participants were asked to type out their answers to two questions about suspicions regarding the study design: "What do you think is the aim of this study?" and "Do you think that something was not told about the experiment?" The aim of these questions was to assess whether participants had guessed the research question or that the opponent was not a real participant, which would have altered their perception of the game and the experiment.

After the control questions, participants were informed that the experiment was finished. They were told about the true nature of the study and the reasons for misleading them and given the participation reward along with the extra movie ticket. The experiment lasted approximately one hour.

2.4.2 Results

To the manipulation check question "How often do you estimate the opponent was looking at you when the window opened and you saw the opponent?" participants estimated, on average, the proportion of trials with direct gaze to be 60.98 % (SD = 23.42, range = 10–95). Because all participants reported having noticed both gaze directions, no participant was excluded based on this question. Two suspicion check questions were used to assess whether participants guessed the research question or the confederate being a research assistant. No one guessed the correct research question. To the question of thinking that something had not been told about the experiment, two female participants reported having suspected that the opponent was not a real participant, and they were excluded from the analysis. Additionally, two participants (one female, one male) were excluded from the lying data analysis due to technical problems in the experimental procedure, and one (male) for not lying at all. One participant (female) was also excluded from the LFQ analysis due to a technical error in the beginning of the questionnaire.

Lying in the game was measured as the number of dishonest responses (i.e., the number of blue circles reported as red). Participants lied, on average, 22.93 times (SD = 13.51, range = 1–50) on the 60 trials with a blue circle. A paired samples t test indicated that participants lied less on trials where the blue circle was preceded by direct gaze (M = 10.96, SD = 6.94) than on those where it was preceded by averted gaze (M = 11.98, SD = 6.98), $t(45) = -2.06$, p =.046, d = -0.30, 95% CI [-0.60, -0.01]. On average, participants made 0.67 mistakes (SD = 1.56, range = 0–6) of reporting having seen blue when shown red, presumably due to lapse of attention or accidentally pressing the wrong key. The number of mistakes did not differ between the two gaze conditions, $t(45) = -0.90$, p = .371, d = -0.13, 95% [-0.42, 0.16].

On the SSAS, no significant difference was observed in participants ratings of public self-awareness, $t(45) = 1.50$, p = .140, d = 0.22, 95% CI [-0.07, 0.51], or of private self-awareness, $t(45) = -0.77$, $p = .446$, $d = -0.11$, 95% CI [-0.40, 0.18], between the two gaze conditions (see Table 7). A TOST with equivalence bounds of $d = \pm 0.30$ did not support the absence of a meaningful difference in public self-awareness, $t(45) = 0.55$, $p = .292$, or in private self-awareness $t(45) = -1.27$, $p = .105$. Similarly to Experiment 2 of Study I, participants reported significantly lower awareness of surroundings in response to direct gaze ($M = 4.01$, $SD = 1.52$) than to averted gaze ($M = 4.27$, $SD = 1.41$), $t(45) = -2.13$, $p = .039$, $d = -0.31$, 95% CI [-0.61, -0.02]. Public self-awareness was proposed to mediate the relation between eye contact and lying but because the predictor (gaze direction) did not have a significant effect on the hypothesized mediator (public self-awareness), mediation was not possible (Baron & Kenny, 1986).

Table 7. Comparison of the SSAS ratings by gaze direction

	Direct		Averted					
Subscale	*M*	*SD*	*M*	*SD*	*t*(45)	*p*	*d*	95% CI
Public	3.21	1.51	2.93	1.51	1.50	.140	0.22	[-0.07, 0.51]
Private	4.29	1.31	4.37	1.16	-0.77	.446	-0.11	[-0.40, 0.18]
Surroundings	4.01	1.52	4.27	1.41	-2.13	.039	-0.31	[-0.61, -0.02]

Note. Adapted from “Eye contact reduces lying” by J. O. Hietanen, A. H. Syrjämäki, P. K. Zilliacus, and J. K. Hietanen, 2018, *Consciousness and Cognition, 66,* p. 69 (https://doi.org/10.1016/j.concog.2018.10.006). Copyright 2018 by Elsevier Inc.

In the LFQ, participants reported having lied, on average, 2.49 times ($SD = 2.98$, range = 0–12) during the last 24 hours. There was a marginally significant positive correlation between the number of lies during the last day and the total number of lies in the game, $r(45) = .27$, 95% CI [-.03, .52], $p = .079$.

3 DISCUSSION

This dissertation focused on the cognitive, affective, and behavioral effects of eye contact and their underlying mechanisms. Three studies were conducted to investigate questions related to these topics.

The aim of Study I was to examine whether the perception of another person's direct gaze induces self-referential processing. This has been previously proposed by Conty and others (2016), but it has not been directly investigated. Three experiments were conducted to investigate this question, two with video and one with live stimuli. In each experiment, participants were randomly assigned to two groups, one presented with a model's face looking directly at them, and the other with a face looking downward. Each stimulus presentation was followed by a trial of an implicit task measuring self-referential interpretation of ambiguous linguistic information. In the experiment with live stimuli, responses of the direct gaze group were found to reflect higher self-referential processing than those of the averted gaze group. In the two video experiments, by contrast, no significant differences emerged between the groups. These findings tentatively suggest that only genuine eye contact induces self-referential processing, whereas the mere perception of direct gaze without being seen by the other person does not.

Study II investigated the roles of being seen by another person and their physical presence on the effects of eye contact. Based on previous research, it is unclear whether the other person's physical presence or proximity is required for the effects. Affective and cognitive responses to direct and averted gaze were measured in live interaction, in a video call interaction, and while watching a mere video presentation of the other person without bidirectional view. Direct gaze was found to elicit greater SCRs indicating greater autonomic arousal than averted gaze in live interaction and during video call, but not in the mere video condition. Facial EMG measurements, by contrast, showed greater facial muscle activity associated with positive affect in response to direct than averted gaze in all study conditions. In other words, the mere perception of direct gaze activated the zygomatic and relaxed the corrugator muscles. Therefore, the results suggest that for the autonomic arousal response to direct gaze, being seen by the other person but not their physical presence is required, whereas, for the facial reactions associated with positive affect, the mere perception of watching eyes is sufficient regardless of being seen by, or in the presence of, the other person. Participants' subjective affective responses to direct and averted gaze were similar in all conditions. Moreover, in contrast to what was expected based on the results of Study I, responses to direct gaze seen live, in video call, or in video were similar on an implicit measure of self-referential processing.

Study III investigated the effect of eye contact on lying. Previous studies have shown that pictures of watching eyes reduce dishonest behavior, but the effect of genuine eye contact on actual lying has not been previously investigated. This was examined by using an interactive lying game that participants played against a confederate of the experimenter, whom they believed to be another participant. Before each turn in the game, participants were presented with the face of the opponent looking at them or downward. Participants' moves in the game that were preceded by the opponent's direct gaze were found to be more honest than the moves they made after seeing averted gaze. This suggests that genuine eye contact may reduce the tendency to lie.

In all three studies, the effect of eye contact on subjective self-awareness was also investigated. Contrary to what was expected and what has been observed in previous studies (e.g., Hietanen et al., 2008; Pönkänen, Peltola, & Hietanen, 2011), no significant differences emerged in public self-awareness between direct and averted gaze or between different presentation modes of direct gaze. Participants' reports of private self-awareness in response to direct and averted gaze were also similar. Interestingly, however, seeing live direct gaze resulted in lower levels of awareness of immediate surroundings than seeing live averted gaze in both studies where it was measured, that is, in Studies I and III.

3.1 Eye contact and self-referential processing

Studies I and II examined the self-referential power of eye contact. Conty and colleagues (2016) have hypothesized that the perception of another's direct gaze elicits self-referential processing (cognitive processing of contextual information in relation to the self) and this could comprehensively account for many of the effects of eye contact. In Study I, this proposed effect was investigated either by showing participants 5-second or 1-second video clips of another person (in Experiments 1a and 1b, respectively) or by showing them a 5-second presentation of another live person through a liquid-crystal shutter window (in Experiment 2). In all experiments, participants were randomly assigned to direct and averted gaze groups, which were presented accordingly with another person either looking directly at them or downward. Self-referential processing was measured as the use of first-person singular pronouns in the interpretation of incomprehensible sentences (foreign-language task by Davis & Brock, 1975; used in all experiments) or comprehensible but incomplete sentences (LIF by Wegner & Giuliano, 1980, 1983; used in Experiments 1b and 2). Increased use of first-person pronouns has been shown to reflect heightened self-focused attention (e.g., Davis & Brock, 1975; Rude et al., 2004; Silvia & Eichstaedt, 2004), and, as the tasks require interpretation of ambiguous information as either self- or other-related, they were proposed to tap into self-referential processing. The direct gaze group used more first-person pronouns than the averted gaze group in Experiment 2, but not in Experiments 1a and 1b. Equivalence tests indicated that, in Experiments 1a and 1b, there were no meaningful increase in first-person pronoun use by direct versus averted gaze. Moreover, when the data of Experiments 1a and 1b were combined and analyzed together, the use of first-person pronouns was significantly *lower* in the video direct gaze groups than in the video averted gaze groups. The most probable explanation for the differing results between the experiments has to do with the use of live instead of video stimuli in Experiment 2. Therefore, these findings tentatively suggest that only genuine eye contact in a live interaction, and not the mere perception of a face with a direct gaze, induces self-referential processing. However, because the results with live and video presentations were obtained in separate, slightly differing experiments, they cannot be directly compared, thus limiting the interpretation of the results.

Study II intended to address this shortcoming by comparing each participant's responses to direct gaze in live interaction, in video call interaction, and in video presentation within a single experiment. Contrary to what was expected, however, in this study, no significant differences were observed in first-person pronoun use between the three direct gaze presentations.

Study II differed from Study I in its design, which may well explain why no differences were observed between the responses in the three conditions. In Study I, self-referential processing was measured with the foreign-language task and a 10-item sentence completion task (LIF) and the responses of two groups, one presented with direct and another with averted gaze, were compared. In Study II, by contrast, a within-subjects design was used, there were only five items of sentence completion in each condition, and each participant completed the same task three times, although with different sentences. These differences in task administration were necessary to avoid excess repetition of the task, but they may have reduced its sensitivity. In Study II, participants also saw the model on many more trials than participants in Study I, which may have caused habituation to the stimulus. Moreover, in Study I, responses to direct and averted gaze were compared, whereas in Study II, live direct gaze was compared to direct gaze presented in a bidirectional video call and in video. An inspection of the results of Study I reveals that, on the LIF, participants' use of first-person pronouns in live direct gaze, video direct gaze, and video averted gaze groups were fairly similar (4.48, 4.21, 4.58, respectively), whereas the perception of live averted gaze resulted in a *lower* number of first-person pronouns (3.57). This implies that another live person's averted gaze may also be a stimulus that reduces self-referential processing, possibly by turning participants' attention elsewhere from the self. However, this is likely not the whole picture, because in the foreign-language task in Study I, the difference between participants' responses is best characterized as higher first-person pronoun use in response to live direct gaze (2.62) than to the other stimuli (e.g., 1.74 for video direct gaze, see Table 4). Be that as it may, it is a limitation of Study II that the responses to direct and averted gaze were not compared within conditions. Taken together, the differences in study designs could well explain the inconsistency between the results of Studies I and II. Therefore, it is clear that the null result of Study II does not undermine the findings of Study I indicating that, in a live interaction, the perception of direct gaze in comparison to averted gaze induces self-referential processing.

Interestingly, in Study I, the perception of live direct gaze resulted in lower use of third-person singular pronouns than the perception of live averted gaze. This incidental finding implies that the tendency to choose first-person pronouns may come specifically at the expense of the third-person pronouns. Hence, a decrease in the use of third-person responses (i.e., a reduction in other-related interpretations) may also indirectly indicate heightened self-referential processing. Similarly, in Study II, there was a marginal difference in third-person pronoun use between conditions, and participants used significantly less third-person pronouns in the live than in the video condition. This may imply a difference in self-referential processing between the two conditions, but it is, at most, only tentative evidence. Based on the present results, the question of whether the self-referential power of eye contact requires a belief of being seen or the other person's presence remains open.

In recent years, other researchers have also investigated whether eye contact or being seen induce self-referential processing. Cañigueral and Hamilton (2019) investigated this by measuring the enhancement of the self-referential memory effect, that is, improved recall of information related to one's self (see Wagner et al., 2012). Participants completed a memory task where they judged adjectives in relation to themselves or to another person either during an alleged video call with a confederate or while watching a mere video of the same person. In contrast to what Cañigueral and Hamilton expected, the magnitude of the self-referential memory effect was similar in the two conditions. They discussed three possible explanations for the discrepancy between Study I of this dissertation and their study. First, the self-referential effect of eye contact may require the physical presence of the other person. Second, in their experiment, the confederate's gaze was always slightly averted (as is common in video calls), and the effect may require a perception of direct gaze. And third, the pronoun-selection tasks used in Study I may engage different cognitive processes than the encoding of task items to memory. For these reasons, and due to a lack of comparison to a live interaction, the study does not yield much light on the question of whether eye contact affects self-referential processing, though it does suggest that self-referential processing may not be affected by a belief of being seen in and of itself.

Studies on interoceptive self-awareness and sense of agency provide some, although mixed, evidence on how eye contact affects self-referential processing. As noted in Introduction, better interoceptive accuracy has been argued to reflect heightened self-referential processing (Isomura & Watanabe, 2020). One study found that seeing a picture of direct in comparison to averted gaze improved interoceptive awareness suggesting that this effect is induced by the mere perception of direct gaze, and, therefore, it does not require being seen by the other person (Baltazar et al., 2014). In contrast with this, another study found that interoceptive accuracy was better after seeing a person in a video call and believing to be seen by them in comparison to not believing so (Hazem et al., 2017). However, yet another recent study that measured temporal binding of one's actions and randomly triggered events, an indicator of sense of agency, found an increase in this effect by the perception of a mere direct gaze picture (Ulloa et al., 2019). The authors argued that the observed increase in the sense of agency indicates that seeing a picture of direct gaze induces heightened self-referential processing. Taken together, these studies provide some evidence that the mere perception of direct gaze may induce self-referential processing and believing to be seen by the other person may further enhance this effect. It may be that a mere direct gaze image induces an automatic sense of being watched (Conty et al., 2016; Pfattheicher & Keller, 2015), but this effect is stronger when one is consciously aware of being observed. Importantly, however, none of these studies investigated how genuine, in-person eye contact affects these phenomena or contrasted the effects of live, video call, or picture presentations of direct gaze on these measures. Therefore, it remains unclear whether these effects extend to genuine eye contact or whether being seen would modulate the effects in that situation. Moreover, as Cañigueral and Hamilton (2019) pointed out regarding their own results, these effects, although all clearly related to self-related cognition, may engage different cognitive processes. More research is needed on the effect of eye contact on self-referential processing and on the role of being seen on this effect.

3.2 Situational self-awareness

Self-awareness (i.e., situational, conscious attention to one's self) is a closely related phenomenon to self-referential processing. In the present studies, it was investigated with the SSAS questionnaire (Govern & Marsch, 2001). On this measure, public self-awareness is defined as situational attentiveness to how one appears to others and private self-awareness as attentiveness to one's internal experience, such as memories and emotions. Public self-awareness was expected to increase by genuine eye contact. However, no significant differences between direct and averted gaze were observed on these two scales in Studies I and III. In Study II, participants' levels of public self-awareness were also similar in response to live, video call, and video presentations of direct gaze. When the null findings were further examined with equivalence tests where applicable (in Studies I and III), the data were found to be inconclusive on whether there was a meaningful increase in public self-awareness by live direct versus live averted gaze.

In previous studies, participants have consistently rated their level of public self-awareness higher in response to live direct gaze in comparison to live averted gaze or to a perception of direct gaze without a belief of being seen (Hietanen et al., 2008; Myllyneva et al., 2015; Myllyneva & Hietanen, 2015; Pönkänen, Peltola, & Hietanen, 2011). The discrepancy between the present and previous studies may be related to validity issues of self-report measures, such as conflicting motives that may affect reporting (Paulhus & Vazire, 2007). For example, participants may not report being "self-conscious about the way I look" (Govern & Marsch, 2001, p. 369), in order to appear more confident. Moreover, the sensitivity of self-reports of self-awareness is hindered by the fact that completing self-reports can itself induce self-awareness (Osberg, 1985). Regarding the present and previous studies, the inconsistency between different studies with similar stimuli suggests that self-evaluation may not be a reliable way to measure situational changes in public self-awareness.

Interestingly, the perception of direct gaze was found to result in lower levels of awareness of immediate surroundings than the perception of averted gaze. This was observed in Studies I and III (in Study II it was not measured) and only in response to live stimuli. This was unexpected, and to our knowledge, no such effect has been observed in previous studies. One possible explanation for these results derives from the theory of objective self-awareness by Duval and Wicklund (1972). The theory posits that conscious attention is bidirectional and directed either to the self or the external world. Because the perception of averted gaze resulted in higher attention to the surroundings than the perception of direct gaze, it may thus reflect reduced self-focus. Conversely, lower attention to the surroundings while seeing direct gaze may be argued to reflect higher self-focus. In fact, the scale of awareness of immediate surroundings in the SSAS was originally developed to be a measure of "non-self-focus" (Govern & Marsch, 2001, p. 368). Because when attention is not focused on the self, it is usually focused on something else, such as the surrounding space, measuring non-self-focus was seen as a useful property for a self-report of self-awareness. Based on these considerations, lower ratings on a scale of non-self-focus in response to live presentations of direct versus averted gaze may be interpreted as indirect support for an increase in self-awareness by genuine eye contact. This interpretation of lowered non-self-focus by live eye contact fits well with the implicit results of Studies I and II showing lower use of third-person pronouns (i.e., less other-related interpretations) in response to live direct gaze than to live averted gaze or to video direct gaze.

On the other hand, lower awareness of surroundings during direct gaze may simply reflect the fact that direct gaze is a stimulus that can attract attention. Studies have shown that a face with a direct gaze can attract and capture attention (Conty et al., 2006; Conty, Gimmig et al., 2010; Senju et al., 2005; Senju & Hasegawa, 2005). Therefore, seeing direct gaze may be expected to reduce the amount of attention given to other objects in the environment, which could also explain the present results. Notably, though, the studies that have shown the attention-capture effect have used pictorial stimuli, whereas in the present studies, lowered awareness of surroundings was only observed in response to live, not video, direct gaze. This suggests that the observed change in situational awareness was not elicited by any effect that would also arise by the perception of a mere direct gaze picture, like the attention-capture effect. In sum, it remains unclear whether the lowered attention to surroundings by live eye contact was caused by increased attention to one's self or by some other mechanism.

3.3 The autonomic arousal response

Study II also investigated what underlies the affective effects of eye contact. Previous research suggests that being seen by the other person may be an essential variable for the affective responses to another person's gaze (Myllyneva & Hietanen, 2015; see also Hietanen et al., 2008; Pönkänen, Peltola, & Hietanen, 2011). They have, however, left it unclear whether the other's physical presence or proximity is also required. To answer this question, Study II compared the psychophysiological and subjective affective responses elicited by direct and averted gaze in a live interaction, in a video call interaction, and while watching a mere video of the other person.

Autonomic arousal responses were higher to the perception of direct than averted gaze only in the live and video call conditions, and not while watching a video presentation of the other person. An equivalence test supported the conclusion that there was no meaningful increase by direct versus averted gaze in the mere video condition. This replicated previous research showing heightened autonomic arousal in live eye contact (e.g., Hietanen et al., 2008; Jarick & Bencic, 2019; Nichols & Champness, 1971; Prinsen & Alaerts, 2019; Pönkänen, Peltola, & Hietanen, 2011) 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). Because 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 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. One may, therefore, argue that such subtle reactions could also explain the observed autonomic arousal responses 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. Yet, the heightened autonomic arousal responses to direct gaze were only observed when participants believed to be seen. Therefore, the most probable explanation for the present and previous results is that the autonomic arousal response to eye contact requires a perception of being seen by another person.

The most important contribution of Study II is extending the knowledge of what underlies the affective responses to eye contact. Previous studies have demonstrated the autonomic arousal response only in settings where the other person is present in the same room thus leaving it unclear whether the other's presence is also required for the effect (Helminen et al., 2011; Hietanen et al., 2008, 2018; Jarick & Bencic, 2019; Myllyneva et al., 2015; Myllyneva & Hietanen, 2015, 2016; Nichols & Champness, 1971; Pönkänen, Peltola, & Hietanen, 2011; Prinsen & Alaerts, 2019). By showing that the perception of direct gaze elicits a greater arousal response than the perception of averted gaze also during video call, Study II demonstrates that the effect does not depend on the other person's physical presence or proximity.

It is, however, possible that the other's physical presence could still have some additional effect on autonomic arousal. Although there was no significant difference in the magnitude of SCR increase by direct versus averted gaze between the live and video call conditions, the magnitude of SCR increase was not found to be statistically equivalent in the two conditions. This may be because of limited statistical power and, in further research, a larger sample is required to investigate this question. Nevertheless, Study II does show that the other person's presence is not required for the autonomic arousal response to eye contact, and that the additional effect of physical presence is either relatively small or nonexistent.

Senju and Johnson (2009) have proposed that the perception of direct gaze is detected in the brain by a subcortical pathway that allows a fast and automatic response to it. According to this fast-track modulator model, subcortical structures detect direct gaze based on crude visual information and they then modulate the cortical processing of information in what is called the social brain network. By bypassing cortical areas, these subcortical structures have also been hypothesized to be able to activate the amygdala directly and thus trigger a rapid, automatic arousal response (LeDoux, 2012). There is considerable evidence to support these proposals, and, regarding eye contact, Burra and others (2013) have shown that the perception of direct gaze does indeed activate the right amygdala directly without cortical processing. Regarding the autonomic arousal response to eye contact, however, the results of Study II and those of Myllyneva and Hietanen (2015) imply that it is not triggered directly by the subcortical pathway. Because this response seems to depend on an inference of the other person's perspective, it is likely that cortical brain areas, possibly those associated with the theory of mind, are involved in its control. Nevertheless, these results are not necessarily in conflict with those of Burra and others (2013) or with the fast-track modulator model. The neural control of autonomic arousal is complex and, in addition to the amygdala, it involves cortical areas and the limbic system (for reviews, see Critchley, 2002; Sequeira & Roy, 1993). Therefore, it is possible that direct gaze is initially detected by the subcortical pathway but that the autonomic arousal response is elicited on a later stage that is dependent on the subsequent modulation of cortical processing.

Studies on social cognition often measure responses evoked by pictures of other people. This is practical and allows a high controllability of stimulus presentation. Importantly, however, the use of pictorial stimuli does not permit any interaction between the observer and the observed people, which has drawn criticism for such study designs. Risko and colleagues (2012) have pointed out that effects observed with pictorial stimuli may not generalize to live encounters and, therefore, responses to "real versus reel stimuli" should be directly compared (p. 1). Schilbach and colleagues (2013) have further argued that interaction has a constitutive role in social cognition, and, for this reason, it should be given priority in social cognition research. The results of Study II demonstrate the utility of comparing live and video stimuli and give support for the second-person approach of Schilbach and colleagues (2013) by showing that the perception of another person does not have the same effects if it is not equipped with a bidirectional view with another conscious mind.

3.4 A gaze can make you smile

In Study II, the perception of direct in comparison to averted gaze was found to increase zygomatic and decrease corrugator muscle activity in all study conditions. This replicates the results of Hietanen and colleagues (2018) showing similar facial EMG responses indicative of positive affect in response to a live person's direct versus averted gaze. More importantly, Study II provides new evidence of these facial reactions by demonstrating that the responses are similar for live, video call, and video presentations of direct versus averted gaze. The present results suggest that, contrary to the arousal responses, the facial reactions are elicited by the mere perception of direct gaze and thus they are not moderated by a perception of being seen by, or the presence of, the other person.

The dissociation between autonomic arousal responses and facial reactions to direct gaze implies that the observed activation of the zygomatic muscle and the relaxation of the corrugator muscle may not reflect a genuine affective experience. These EMG responses often indicate positive emotional reactions (e.g., Dimberg et al., 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 reflexive reaction of smiling to the perception of a face looking your way. The results of Study II support this proposal because the facial reactions were dissociated from autonomic arousal, suggesting possible dissociation from affective experience, and because they were also observed in response to a mere video, suggesting that they were not communication of motives to the other person. In future research, the measurement of *orbicularis oculi* muscle activity could shed light on the question of whether the facial reactions to eye contact reflect an automatized response or an affective experience. This is because the simultaneous activation of the orbicularis and zygomatic muscles (i.e., Duchenne smile) may be a better indicator of a positive emotions than the activation of the latter alone (Frank & Ekman, 1993; cf. Schmidt et al., 2006).

In contrast to the present results, a recent study by Hietanen and others (2019) found that facial EMG responses may be sensitive to the belief of being seen. The study found some evidence indicating that the zygomatic responses to neutral faces with direct gaze may be inhibited when participants believe to be seen. However, because in that study the responses to faces with a neutral expression were compared to faces with a smile, the authors argued that participants may have contrasted the two and thus perceived the neutral expression as negative. This may have led participants to consciously inhibit their automatic smiling response to a negative expression when it was directed at them personally, that is, when they believed to be seen. This seems plausible and could account for the seeming discrepancy between the results of that study and Study II. Overall, it seems that the perception of direct gaze does elicit an automatic zygomatic response, but this response may be mitigated by factors related to context and interpretation.

3.5 No changes in subjective experiences of affect

The results of Study II indicated no significant differences in subjective evaluations of valence or arousal between the gaze directions or conditions. This is in contrast with the physiological results, although such inconsistencies are not uncommon between measurements of subjective and psychophysiological responses (e.g., Lang et al., 1993; Rosebrock et al., 2017). The present results also contradict those of previous studies that have shown a gaze direction effect on both scales (Hietanen et al., 2008; Pönkänen, Alhoniemi, et al., 2011; Uono & Hietanen, 2015). One possible explanation for this discrepancy is a difference in the way the evaluations were conducted. In Study II, 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 stimuli again. In most previous studies, by contrast, participants were asked to respond based on recall of how they felt during the preceding stimulus presentations. It is plausible that online evaluation of valence and arousal during stimulus presentations leads to different, possibly more accurate, responses than retrospective evaluation, which is known to be influenced by a variety of recall biases (e.g., Gorin & Stone, 2001). It is noteworthy, however, that one study that found a gaze direction effect on these scales did not use retrospective, but online evaluation (Uono & Hietanen, 2015). Another possible explanation for the inconsistent results stems from the large number of trials that preceded the evaluation in Study II. In comparison to the previous studies, participants were presented with the same stimulus face a much larger number of times before the evaluations, which could have caused habituation. Overall, it seems possible that factors related to the study design may explain the discrepancy between Study II and the previous studies. It is, however, unclear, whether the present results provide a more accurate or a less accurate picture of the subjective experience during eye contact than the previous studies, and the possibility of a type II error cannot be discounted.

3.6 The effect of eye contact on dishonesty

Study III investigated whether eye contact reduces lying. The perception of direct gaze in comparison to averted gaze was found to reduce subsequent lying in an interactive game. Previous studies have demonstrated that seeing an image of watching eyes can reduce dishonest behavior (Bateson et al., 2006; Nettle et al., 2012; Oda et al., 2015; Siebenaler et al., 2018). Study III extends previous research by showing this effect with a live person instead of an image as the stimulus. This is important because, as Risko and colleagues (2012) among others have argued, the effects observed with pictures should not be automatically expected to generalize to more naturalistic, interactive situations. Furthermore, previous studies have compared the honesty effect of seeing a watching-eyes image to either seeing a different kind of image, such as a picture of flowers (e.g., Bateson et al., 2006), or to seeing no image at all (Nettle et al., 2012; Oda et al., 2015). Thus, they have left it unclear whether it is the face or the gaze that causes the effect. Study III expands on the previous findings by showing that it is the perception of direct gaze, not that of a face or eyes, that induces the effect.

Study III demonstrated that the perception of direct gaze can reduce dishonesty in a situation where it cannot be explained by increased rule adherence or cooperation. In previous studies, the effect of watching eyes on dishonesty has only been shown on behaviors that have been clear violations of norms and rules, such as stealing (Nettle et al., 2012), taking drinks without paying (Bateson et al., 2006), or lying to experimenters (Oda et al., 2015; Siebenaler et al., 2018). In Study III, by contrast, lying was not against the rules. The effect was investigated by using a lying game wherein occasional dishonesty was allowed and expected and thus clearly normative. Moreover, most of the behavioral effects of watching eyes that previous studies have demonstrated can be interpreted as an increase in cooperative behavior. This can account for a variety of previous findings, such as increased helping (Manesi et al., 2016) and generosity (Haley & Fessler, 2005; Powell et al., 2012), and reduced littering (Bateson et al., 2013, 2015; Ernest-Jones et al., 2011), in addition to those related to reduced dishonesty. Ernest-Jones and others (2011) have argued that the primary effect of seeing watching eyes is increased cooperative behavior, which has its roots in human evolution. In Study III, however, reduced lying in a competitive, head-to-head game can hardly be seen as increased cooperation. By showing the watching-eyes effect in a situation where the change in behavior cannot be accounted for by an increase in norm adherence or cooperation, Study III extends the knowledge on the many ways the perception of watching eyes may influence behavior.

Study III showed the watching-eyes effect on dishonesty in a situation where the recipient or sufferer of the lie was the same person as the person looking directly or downward. Seeing another person with a direct gaze may increase empathy towards that person (Schulte-Rüther et al., 2007). Therefore, it is possible that the effect was caused by empathy towards the gazing person (i.e., not wanting to harm that person in particular) and not by a reduction in dishonest behavior per se. One may argue that this is unlikely, because seeing a watching-eyes image has been shown to have a similar effect, which the empathy explanation cannot account for (Bateson et al., 2006; Nettle et al., 2012; Oda et al., 2015; Siebenaler et al., 2018). However, as noted earlier, seeing a sheer image is very different from seeing a real person and thus it is possible that the effects observed with pictorial stimuli do not have the same underlying mechanism as those elicited by the perception of a live person. A recent study by Mol and others (2020) provides evidence that fills this gap between Study III and previous studies. By using an immersive virtual reality (VR) environment, they showed that seeing another person's direct gaze reduced dishonest behavior by itself. In that study, participants were in a virtual pub where they played a slots game wherein cheating was possible. Participants who saw a realistic avatar looking at them were found to cheat less than those for whom the avatar was looking downward and watching his smartphone. Because the avatar was not the recipient of the dishonesty, the empathy explanation cannot account for the result. Although the study was not conducted in a real environment, the VR environment was more similar to a live interaction than seeing an image of eyes, and previous studies support the validity of using VR environments to study responses to social interactions (e.g., Pan & Hamilton, 2018; Rubo & Gamer, 2018). Therefore, the evidence as a whole clearly suggests that seeing another person's direct gaze reduces dishonesty in and of itself.

Because the dependent variable was a measure of behavior in interaction with another person, the perception of the other's gaze could not be contrasted with the perception of a mere gaze image. Therefore, Study III leaves it unclear whether the effect of live direct gaze on lying is different from that elicited by a mere image of watching eyes. This seems plausible, because believing to be seen influences many of the effects of eye contact (for a review, see Conty et al., 2016). Moreover, in other contexts, a belief of being watched in itself has been found to reduce socially undesirable behavior. Studies using eye trackers, for example, have demonstrated that believing that one's gaze direction is being recorded reduces inappropriate gaze behavior (Nasiopoulos et al., 2015; Risko & Kingstone, 2011). Taken together with the evidence of the effects of watching-eyes images, it appears that both seeing the watching-eyes stimulus and believing to be seen can reduce undesirable behavior, like lying. It remains for further studies to investigate how these effects compare to each other, how they interact, and whether they involve the same psychological mechanisms.

In Study III, the generalizability of lying in the game to lying in everyday life was examined with a self-report questionnaire. On the questionnaire, participants were instructed to think back over the last day and count and report the number of times they had lied to someone. A marginally significant positive correlation between lying in the game and reported lying in the past day was observed. This result is suggestive evidence of similarity in participants' lying behavior in everyday life and in the game and it thus supports the external validity of the game and its use in the measurement of dishonest tendencies. However, because the correlation was not statistically significant, the result is only tentative and should be interpreted with caution.

3.7 Limitations

The present study designs impose some limitations on the implications of the results. First, because the measures of self-referential processing, affective responses, and dishonest behavior were confined to very specific responses, these studies should not be considered a thorough investigation of how the perception of direct gaze affects self-referential cognition, emotional experience, or dishonest behavior. Second, the demonstrated effects do not necessarily extend to natural social interactions, because they were investigated in simplified situations and in laboratory conditions. Further research is needed to determine what kind of cognitive, affective, and behavioral effects another person's gaze direction has in more complex situations, such as, for example, collaborative work or psychological interventions. Moreover, the results of Study II showing similar affective responses to eye contact in video call and in-person interactions may not extend to the use of present-day videoconferencing technologies. This is because, in these applications, the other person is usually seen 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, and seeing direct gaze may be an essential variable for these responses.

3.8 Conclusions

The present studies investigated the effects of eye contact on self-referential processing, autonomic arousal, facial reactions associated with positive affect, and dishonest behavior. Seeing another live person's direct in comparison to averted gaze was found to increase self-referential processing and reduce lying. Eye contact was found to elicit a heightened autonomic arousal response that depends on being seen by the other person but not their physical presence. By contrast, facial reactions associated with positive affect were elicited by the mere perception of direct gaze and thus they do not depend on being seen by the other person or their physical presence.

Eye contact is a powerful social signal with varying effects on human cognition, emotion, and behavior. This dissertation broadens the knowledge of the effects of eye contact and their underlying mechanisms and highlights their multifaceted, context-dependent nature.

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Genuine eye contact elicits self-referential processing

Jonne O. Hietanen, Jari K. Hietanen *

Human Information Processing Laboratory, Faculty of Social Sciences/Psychology, University of Tampere, Finland

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ABSTRACT

The effect of eye contact on self-awareness was investigated with implicit measures based on the use of first-person singular pronouns in sentences. The measures were proposed to tap into self-referential processing, that is, information processing associated with self-awareness. In addition, participants filled in a questionnaire measuring explicit self-awareness. In Experiment 1, the stimulus was a video clip showing another person and, in Experiment 2, the stimulus was a live person. In both experiments, participants were divided into two groups and presented with the stimulus person either making eye contact or gazing downward, depending on the group assignment. During the task, the gaze stimulus was presented before each trial of the pronoun-selection task. Eye contact was found to increase the use of first-person pronouns, but only when participants were facing a real person, not when they were looking at a video of a person. No difference in self-reported self-awareness was found between the two gaze direction groups in either experiment. The results indicate that eye contact elicits self-referential processing, but the effect may be stronger, or possibly limited to, live interaction.

1. Introduction

In face-to-face contact, the gaze is mostly directed to another individual's eye region (Itier, Villate, & Ryan, 2007). The orientation of another's eyes communicates the direction of their attention and potential targets for intentions (Itier & Batty, 2009). Another individual's averted gaze informs the observer that there is something conceivably interesting and important in the environment, and, indeed, an extensive line of research has indicated that seeing another's averted gaze triggers and automatic shift of the observer's visual attention in the same direction (e.g., Driver et al., 1999; Friesen & Kingstone, 1998; Hietanen, 1999; Langton & Bruce, 1999). But what about if the perceived gaze is directed at the self? In mutual gaze (eye contact), the self is the object of another's attention. Another's direct gaze has been shown to attract (Conty, Tijus, Hugueville, Coelho, & George, 2006; Senju, Hasegawa, & Tojo, 2005; von Grünau & Anston, 1995) and capture (Palanica & Itier, 2012; Senju & Hasegawa, 2005) the perceiver's attention, but is it possible that just as observing another's averted gaze at an object shifts the observer's attention to the same target, a gaze directed at an observer should turn the observer's attention upon themselves? It has been proposed that conscious attention is a bidirectional phenomenon, focused either inward toward the self or outward toward the external world, and when attention is directed to the self, it brings about self-awareness (Duval & Wicklund, 1972). Furthermore, it has long been theorized that eye contact turns the attention on the self, thereby increasing self-awareness (Argyle, 1975). Reddy (2003) has proposed that when engaged in eye contact,

* Corresponding author at: Human Information Processing Laboratory, Faculty of Social Sciences/Psychology, FI-33014 University of Tampere, Tampere, Finland.

E-mail address: jari.hietanen@uta.fi (J.K. Hietanen).

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even infants as young as two months old are aware of others focusing attention on them and show reactions of self-awareness as a result. More recently, Conty, George, and Hietanen (2016) proposed that eye contact elicits self-referential processing – an information processing mode relating external information to the self, thus, facilitating and integrating perception and memory (Sui & Humphreys, 2015). They suggested that self-referential processing can, in fact, explain many of the effects of eye contact on cognition, one of them being the hypothesized enhancement of self-awareness. However, regardless of a lot of speculation, the effect of eye contact on self-referential processing and self-awareness has been little investigated.

Self-awareness entails more than just self-focused attention (Hull & Levy, 1979), though many other researchers have used these two terms interchangeably. Hull and Levy (1979) proposed a defining feature of self-awareness to be an enhanced sensitivity to self-relevant information in the immediate situation that serves to increase the understanding of the contingencies of the situation related to one's present activities. Self-awareness also involves the activation of self-knowledge, a process which further guides subsequent perception of the situation (Hull, Van Treuren, Ashford, Propsom, & Andrus, 1988). They referred to this phenomenon as self-relevant encoding, but today the terms self-referential encoding and self-referential processing are more used in the literature. We propose that self-awareness can be conceptualized as comprising of an explicit and implicit component, the former corresponding largely to self-focused attention, and the latter to self-referential processing.

Self-awareness is a transient state and it can be directed to different sides of the self (Fenigstein, Scheier, & Buss, 1975; Govern & Marsch, 2001). Public self-awareness refers to the concern of how one presents oneself and how one is perceived by others. It often emerges in situations such as giving a presentation or being photographed, and it is associated with evaluation apprehension (Alden, Teschuk, & Tee, 1992). By contrast, private self-awareness is an introspective state, characterized by examination and reflection on one's thoughts, feelings, and life (Govern & Marsch, 2001). Introspective self-awareness has been proposed to refine the perception of one's experience and facilitate self-knowledge (for a review, see Silvia & Gendolla, 2001). Enhanced self-awareness is associated, for example, with more accurate self-reports of sociability and dominance behavior (Pryor, Gibbons, Wicklund, Fazio, & Hood, 1977; Turner, 1978). Interoceptive awareness is yet another aspect of self-awareness characterized by awareness of afferent interoceptive signals from one's own body. Interoceptive self-awareness has been proposed to sharpen the perception of internal states, such as arousal and emotions (Silvia & Gendolla, 2001), and it has been found to enhance the perception of one's own heartbeat (Ainley, Maister, Brokfeld, Farmer, & Tsakiris, 2013; Ainley, Tajadura-Jimenez, Fotopoulou, & Tsakiris, 2012). Previous research has manipulated the level of self-awareness in a variety of ways. Efficient manipulations have included listening to recordings of one's own voice (Wicklund & Duval, 1971), being in front of cameras (Davis & Brock, 1975), writing about oneself (Silvia & Eichstaedt, 2004), running in place in an embarrassing way (Wegner & Giuliano, 1983), seeing one's reflection in a mirror (Wicklund & Duval, 1971), and being observed by an audience (Carver & Scheier, 1978).

Considering the relatively large amount of research on self-awareness and the well-established notion that self-awareness can be efficiently induced by exposing one to other individual's observation, it is, perhaps, surprising that the effect of eye contact, the most intimate form of direct observation, on self-awareness has received so little attention. Only relatively recently Hietanen, Leppänen, Peltola, Linna-aho and Ruuhiala (2008), Myllyneva, Ranta and Hietanen (2015) and Pönkänen, Peltola and Hietanen (2011) demonstrated the effect of eye contact on self-reported evaluations of self-awareness. They measured self-awareness with the Situational Self-Awareness Scale, which is probably the most widely used tool for the purpose (SSAS; Govern & Marsch, 2001). SSAS is a self-report questionnaire that includes two subscales of self-awareness, awareness of the public and of the private side of the self, and a control scale of awareness of immediate surroundings to measure attention focused on other targets than the self. In the studies by Hietanen et al., SSAS ratings were measured while the participants were looking at another person who either made eye contact or had an averted gaze. In all of the studies, higher levels of public self-awareness were measured in response to eye contact compared to averted gaze. The ratings of private self-awareness or awareness of immediate surroundings did not differ between the gaze conditions.

In another recent study, Baltazar et al. (2014) demonstrated the effect of eye contact on interoceptive self-awareness. Participants were presented with pictures of either a face with direct gaze or averted gaze, or a picture of a fixation cross on the screen. The picture of a face or a cross was followed by an emotional picture after which the participants evaluated their arousal response to the emotional picture. Skin conductance responses to the emotional pictures were recorded, and the correlations between the subjective ratings and the physiological responses were calculated. The results showed that the participants rated their subjective arousal to the emotional pictures more consistently with the objective measures of their physiological arousal after having seen direct gaze than averted gaze pictures. The authors proposed that the results were best explained by an enhancement of interoceptive self-awareness induced by eye contact.

The studies of the effects of eye contact on self-awareness by Hietanen et al. (2008), Myllyneva et al. (2015) and Pönkänen et al. (2011) relied exclusively on explicit self-report measurements. Even though self-evaluations have the advantage of being able to reveal conscious attitudes and emotions they may also suffer from serious shortcomings. People may have conflicting motives affecting their reporting, and even when attempting to answer honestly and accurately, they can be limited in their capacity to accurately evaluate their own state (Paulhus & Vazire, 2007). Of specific limitation for self-awareness research are findings demonstrating that completing self-report questionnaires can, in fact, increase self-awareness (Osberg, 1985), presumably because of the introspection it requires (Eichstaedt & Silvia, 2003). In this regard, the above cited study by Baltazar et al. (2014) reporting enhanced accuracy of interoceptive evaluations in the context of direct gaze is an important finding because it relied on an indirect measure of self-awareness. However, sharpened interoception is a very specific effect of self-awareness, and further research examining more general aspects of self-awareness is warranted.

To overcome the shortcomings related to explicit self-reports, researchers have also developed implicit measures of self-awareness (Davis & Brock, 1975; Exner, 1973; Wegner & Giuliano, 1980, 1983). These measures consist of linguistic tasks in which the frequency of self-reference in participants' responses is counted. The most evident form of self-reference is the use of first-person singular pronouns, such as "I", "me", and "mine". In linguistic research, high and low frequency of first-person pronouns in creative writing have been associated with self-attachment/immediacy and self-distancing, respectively (e.g. Pennebaker & King, 1999). Individuals who are emotionally focused on themselves have been found to be particularly inclined to use first-person pronouns (e.g. Rude, Gortner, & Pennebaker, 2004), whereas people have been observed to reduce their use of first-person pronouns in a context of psychological distancing (Cohn, Mehl, & Pennebaker, 2004). Similarly, in the pronoun-selection task of self-awareness devised by Davis and Brock (1975), the frequency of first-person singular pronouns in participants' responses is used as an indicator of self-focus and heightened self-awareness. In this task, participants read sentences written in a language they do not understand (e.g., Swahili). The pronouns in the sentences are underlined, and the participants' task is to determine which English pronouns correspond to the pronouns in the sentences. The participants are led to believe that the task is a measure of sensitivity to foreign languages. In the study by Davis and Brock (1975), self-awareness was manipulated by the use of a television camera directed towards the participants. On average, participants in the camera condition chose 30 percent more first-person singular pronouns than participants in the no-camera condition. Another pronoun-selection measure of implicit self-awareness is the Linguistic Implications Form (LIF; Wegner & Giuliano, 1980, 1983). The LIF includes 20 incomplete sentences, each with a blank, that are completed by choosing pronouns to fill in the blanks. There are three alternatives for each sentence, one of which is always first-person singular. All of the alternatives are grammatically correct, and participants are instructed to choose the one they feel best fits the sentence. LIF is a widely used measure of self-awareness, and it has been found to be sensitive to many kinds of manipulations of self-awareness (Salovey, 1992; Silvia & Abele, 2002; Silvia & Eichstaedt, 2004; Snow, Duval, & Silvia, 2004; Stephenson & Wicklund, 1984; Wegner & Giuliano, 1980, 1983).

The methods based on pronoun selection have been suggested to measure self-awareness. We propose that an increase in the use of first-person singular pronouns in one's responses is particularly indicative of enhanced self-referential processing. An enhanced use of self-referring pronouns reflects an increased accessibility of self-related cognitions (Wisman, Heflick, & Goldenberg, 2015) and an enhanced perception of external information as being related to the self, both of which are central to self-referential processing (Hull & Levy, 1979; Hull et al., 1988). In the current study, we report two experiments investigating the effect of eye contact on self-referential processing. We also collected explicit ratings of self-awareness with a self-report questionnaire (SSAS; Govern & Marsch, 2001).

2. Experiment 1

In Experiment 1, the effect of eye contact on self-referential processing was examined with an implicit measure based on pronoun selection in a foreign-language task (Davis & Brock, 1975). On each trial, participants were presented with a video clip of a person with direct or averted gaze followed by a multiple-choice task regarding sentences in foreign languages. In each sentence, one pronoun was underlined, and participants' task was to guess which one of six possible Finnish translations for the target word is correct. Participants were randomly assigned to two groups: participants in one group were presented with video clips of a person with direct gaze, and those in the other group were presented with video clips of a person with averted gaze. A between-subjects design was used for two reasons. First, by presenting only one condition to each participant, the possible carryover effect of self-awareness from one condition to another was avoided. Second, we did not want the participants to be able to contrast the two experimental conditions against each other, which would likely alter their perception of them. To increase the potential effect of gaze direction, all participants were instructed to imagine that the person in the video was a real person. It was expected that participants in the direct gaze group would choose more first-person singular pronouns than participants in the averted gaze group. Participants also completed the Situational Self-Awareness Scale (Govern & Marsch, 2001). On the SSAS, the perception of direct gaze was expected to elicit higher ratings public self-awareness than the perception of averted gaze.

2.1. Method

2.1.1. Participants

The participants were 62 adults (age range = 19–31 years, mean age = 23.9 years, $SD = 3.2$; 33 females) recruited from e-mail lists of the University of Tampere, Tampere University of Technology, and Tampere University of Applied Sciences. The participants were all native speakers of Finnish with no history of neurological or psychiatric disorders. Participants were rewarded with a movie ticket, a 10-euro gift card to a retail chain, or course credit. The study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki). All participants gave their written informed consent.

2.1.2. Materials

The stimuli were video clips of a person with either direct gaze or averted (downward) gaze. Two males and two females acted as model persons. During preparation of the video clips, the model persons were asked to maintain a neutral expression and sit as still as possible without any gross facial, head, or body movements, but blinking was allowed. The models were filmed against a dark background. Two videos were made with each model, one with a direct gaze and another with a downward gaze. The videos did not contain a sound track.

The video clips were presented on a 19-inch LCD monitor with a resolution of 1280 $\times$ 1024. The participants were seated 100 cm from the computer screen. The videos had a resolution of 1024 $\times$ 768 and they were shown on full screen. The face of the model person covered a visual angle of approximately 11° horizontally and 15° vertically. For an illustration of the stimuli, see Fig. 1.

The pronoun-selection task was presented on the same LCD monitor as the video clips. The task consisted of multiple-choice trials regarding sentences in foreign languages. In each sentence, one pronoun was underlined, and the task was to guess which one of the six possible Finnish translations for the target word was correct (see Appendix A for an English translation of the task). The six answer options were pronouns in each particular grammatical person, all conjugated in the same form. For each trial, the options were presented in a different, randomized order. The first 10 sentences were in Swahili, followed by 10 sentences in Basque. The sentences were extracted from language books (Benjamin, Mironko, & Geoghegan, 1998; King, 1994; Mohamed, 2001). The task included following types of sentences: *Nakaa na dada yangu* (I live with my sister) and *Gu fruta saltzen ari gara* (We sell fruits).

2.1.3. Design and procedure

Participants were randomly assigned to two groups, one that was presented with direct gaze videos and another that was presented with averted gaze videos. For each participant, the model person was looking at the same direction at all times. The genders and identities of the models as well as their gaze directions were counterbalanced across participants' gender. Three to four participants took part in the study at the same time in the same room. In each session, at least one of the participants was assigned to a different group (direct gaze vs. averted gaze) than the others. The computers were located in small cubicles. The participants wore earmuffs during the experiment.

Upon arrival to the laboratory, participants were informed on the general aspects of the experiment. They were told that that the experiment would be carried out on a computer and it would include tasks that would be later instructed on the computer screen. Participants were seated in the cubicles and a written consent was obtained. Before beginning the tasks, the participants filled in information regarding their age and gender. The experimenter announced that during the experiment he would be seated behind a partition wall and not be able to observe the participants.

The foreign-language task began with detailed instructions on how the task would be carried out. In the instructions, participants were explicitly told that they were not expected to know the answer, but to guess the word instead. To strengthen the effect of the gaze, the participants were instructed to imagine that the person in the video were a real person sitting opposite to them; someone they could see, hear, talk to, and touch. The task included 20 trials, each of which consisted of a 5-s video of a person and one multiple-choice task. The person in the video was gazing straightforward or downward, depending on the participant's group assignment. After each video clip, a task item and its answer options were presented on the screen. After choosing one of the six answer options, the next trial began immediately.

After the foreign-language task, the computer program presented the participants with the Situational Self-Awareness Scale (Govern & Marsch, 2001). The SSAS measures three forms of situational awareness (public self-awareness, private self-awareness, and awareness of immediate surroundings), each of which is measured with three items. The items were translated to Finnish and modified so that they referred to the moment of watching the videos instead of the present moment. Public self-awareness was measured with items such as "I was concerned about the way I present myself", private self-awareness with items such as "I was conscious of my inner feelings", and awareness of immediate surroundings with

Fig. 1. Still images extracted from the video clips to illustrate the face stimuli used in Experiment 1.

items such as "I was keenly aware of everything in my environment". Participants were instructed to answer based on how they were feeling when they were watching the eye gaze videos. All items were answered on a 7-point Likert scale, ranging from strong disagreement to strong agreement. After the SSAS items, three manipulation check items were presented. The participants were asked to self-evaluate whether the person they saw had looked like he or she was looking directly at the participant, and whether the participant had understood the sentences in Swahili or the sentences in Basque. These items were also answered on a 7-point Likert scale, ranging from strong disagreement to strong agreement.

After all the participants had completed the task and the questionnaires, the experimenter debriefed the participants, thanked them, and gave them the participation rewards.

2.2. Results

2.2.1. Manipulation checks

All participants correctly perceived whether the video model was looking at them or away from them. On a scale ranging from 1 (strongly disagree) to 7 (strongly agree), most of the participants in the direct gaze group strongly agreed ($M = 6.45$, $SD = 0.72$) with the statement "The person in the video appeared to be looking at me", whereas most of the participants in the averted gaze group strongly disagreed ($M = 1.26$, $SD = 0.77$) with the statement, $t(60) = 27.32$, $p < 0.001$, $d = 6.96$. Participants reported that they had not understood the foreign languages in the foreign-language task. The mean score to the statement "I understood the sentences in Swahili" was 1.05 ($SD = 0.28$), and to the statement "I understood the sentences in Basque", the mean score was 1.05 ($SD = 0.22$).

2.2.2. The foreign-language task

Self-awareness was measured as the number of first-person singular pronoun responses. On average, the direct gaze group gave 1.74 first-person responses ($SD = 1.29$), and the averted gaze group 2.16 responses ($SD = 1.24$). A t test showed no statistically significant difference in the number of first-person pronoun responses between the two gaze groups, $t(60) = 1.30$, $p = 0.197$, $d = 0.33$. The use of other pronouns did not differ between the two groups either. The mean number of responses in each grammatical person is shown in Fig. 2.

2.2.3. Situational Self-Awareness Scale

For the SSAS ratings, a t test indicated no significant differences between the direct gaze and averted gaze group in their ratings of public self-awareness ($M_{\text{direct}} = 2.34$; $M_{\text{averted}} = 2.44$), $t(60) = 0.29$, $p = 0.77$, $d = 0.07$, private self-awareness ($M_{\text{direct}} = 4.01$; $M_{\text{averted}} = 3.69$), $t(60) = 1.06$, $p = 0.30$, $d = 0.27$, or awareness of immediate surroundings ($M_{\text{direct}} = 2.86$; $M_{\text{averted}} = 3.17$), $t(60) = 0.90$, $p = 0.37$, $d = 0.23$.

2.3. Discussion

Experiment 1 investigated whether eye contact elicits self-referential processing. The participants were randomly assigned to two groups, one group seeing video clips of models gazing directly at them and the other seeing video clips of the same models looking downward. Self-referential processing was measured with a foreign-language task (Davis & Brock, 1975). In the task, participants were presented with sentences in foreign languages with one pronoun underlined

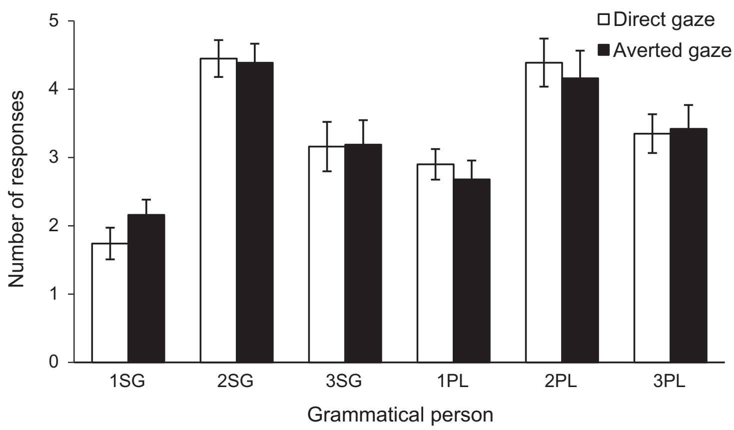

Fig. 2. Mean numbers (and standard errors) of responses in each grammatical person in the foreign-language task by participants in the direct gaze and averted gaze groups, in Experiment 1. Grammatical persons: 1 SG = first singular, 2 SG = second singular, 3 SG = third singular, 1PL = first plural, 2PL = second plural, 3PL = third plural.

and an assignment of guessing the correct meaning of each underlined pronoun. It was expected that participants in the direct gaze group would give more first-person pronoun responses compared to participants in the averted gaze group.

Contrary to the hypothesis, no difference was found in the number of first-person-pronoun responses between the two groups. This finding was somewhat surprising considering that, in previous studies, eye contact has been found to consistently induce explicit self-awareness (Hietanen et al., 2008; Myllyneva et al., 2015; Pönkänen et al., 2011) as well as implicit interoceptive self-awareness (Baltazar et al., 2014). Moreover, the foreign-language task has been demonstrated to be sensitive to different kinds of self-awareness manipulations (Davis & Brock, 1975; Wisman et al., 2015).

Three possible explanations arise for the unexpected results. First, in the present study, participants attended the experiment in groups of three to four people, whereas in the aforementioned studies (Baltazar et al., 2014; Hietanen et al., 2008; Myllyneva et al., 2015; Pönkänen et al., 2011) each participant performed the task alone with no other participants present. The presence of others has been demonstrated to increase public self-awareness (Franzoi & Brewer, 1984) and it is, thus, possible that, in this condition, the effect of the gaze direction manipulation was not strong enough to exert an effect on the implicit pronoun-selection task. However, it should be noted that the participants were seated in separate cubicles and they were not in contact with each other during the experiment. Moreover, in our previous studies, participants were not completely alone, but in the same room with the experimenter, although the experimenter was seated behind a partition wall (Hietanen et al., 2008; Myllyneva et al., 2015; Pönkänen et al., 2011). Therefore, we do not find this explanation likely for the observed null findings.

Another possible explanation for not obtaining the expected results is related to the pronoun-selection task. In the task, heightened self-referential processing was expected to result in increased perception of the foreign-language sentences as self-referring, and this should have increased the number of first-person pronoun choices. However, as the sentences and target words were incomprehensible to the participants, they may have paid little attention to the pronoun choices and made their choices arbitrarily. Moreover, as the target words were different in every trial, participants may have reasoned that the correct answer was probably different, too, resulting in a fairly balanced number of answers in each person-pronoun category. Either answering tendency may have reduced the effect of gaze direction on the pronoun choices.

A third possibility for not finding an effect of eye contact on self-awareness is related to the used stimuli. Videos of model persons making eye contact or gazing downward were used as stimuli. To strengthen the effect, participants were asked to imagine that the person in the video were real. Yet the experience was likely different to eye contact with a live person. In fact, in our previous studies, the effect of gaze direction on explicitly measured public self-awareness was observed only when the participants were looking at a live person, but not when looking at an image of the same person on a computer screen (Hietanen et al., 2008; Pönkänen et al., 2011). It was suggested that this finding reflected the participant's experience of being the object of another person's attention. More recent studies from our laboratory have provided evidence for this possibility. Myllyneva and Hietanen (2015) showed that when participants were led to believe that a one-way mirror was placed between the model and the participant in such a way that the model person would not be able to see the participant, public self-awareness in response to direct gaze was lower than in the condition where the participants believed that they were seen by the model person. And yet, the visual stimulus was exactly the same in both conditions. The belief of being watched by another person has also been shown to be critical for the effects of eye contact on various gaze direction sensitive physiological and cognitive responses (Hietanen, Myllyneva, Helminen, & Lyyra, 2016; Myllyneva & Hietanen, 2015). Thus, it is possible that the effect of eye contact on self-referential processing can also be observed only in the context of genuine eye contact with a live person.

Admittedly, in the study by Baltazar et al. (2014), the effect of eye contact on self-awareness was observed when showing mere face images on a computer screen. However, as noted earlier, the enhanced accuracy of interoceptive evaluations observed in their study is a very specific effect, and it is possible that self-referential processing as measured in the present study is a phenomenon that can be dissociated from interoceptive self-awareness. Nevertheless, their results importantly demonstrate that the mere perception of watching eyes can lead to an enhancement of a certain aspect of self-awareness. It is worth pointing out that their study differs from the present study as well as from our previous studies (Hietanen et al., 2008; Myllyneva et al., 2015; Pönkänen et al., 2011) in one important respect, which may also account for the differing results. In the Baltazar et al. (2014), participants were primed with the direct gaze image only for 1.5 s before an emotional picture was shown, whereas in the present study and our previous studies the direct gaze image was looked at for 5 s at a time. Conty et al. (2016) proposed that the self-awareness effect of eye contact may be canceled out when it is consciously dissociated from the experience of being observed by another. A briefly presented direct gaze image could possibly automatically trigger an experience of being watched, but when a direct gaze image is consciously attended to, it is dissociated from the experience of being observed by another and the effect is attenuated. Moreover, in our previous studies, the direct gaze image was contrasted with the live person's gaze, which may have further augmented the perceived difference between the two.

Based on the above reasoning, we decided to conduct another experiment. Three modifications were made for Experiment 2. Firstly, instead of using video clips as stimuli, live faces were used. Secondly, as the foreign-language task may have been limited in its ability to capture self-referential processing, another pronoun-selection task, the Linguistic Implications Form, was included (LIF; Wegner & Giuliano, 1980, 1983). The key difference between the two tasks is that, in the LIF, the presented sentences are in the participants' mother tongue. The LIF measures the interpretation of a comprehensible context as self-referring or other-referring, and it may thus be better able to assess self-referential processing. Thirdly, as the presence of others may have affected the participants' self-awareness (Franzoi & Brewer, 1984), in Experiment 2, the data were collected from one participant at a time.

3. Experiment 2

In Experiment 2, instead of video clips as in Experiment 1, faces of live models presented through a liquid crystal (LC) shutter served as stimuli. For the measurement of self-referential processing, two pronoun-selection tasks were used: the foreign-language task (Davis & Brock, 1975) and the Linguistic Implications Form (LIF; Wegner & Giuliano, 1980, 1983). The tasks were presented on a computer screen placed on a table between the participant and the model. Like in Experiment 1, in the foreign-language task, the participants' task was to guess translations for underlined pronouns in sentences they did not understand. In the LIF, the participants' task was to choose the best-fitting pronoun option to an incomplete sentence. All of the pronoun options were grammatically correct. In both tasks, each trial consisted of a presentation of the face of a model person with direct or averted gaze through the LC shutter followed by a multiple-choice task on the computer screen. The participants were divided into two groups: participants in the direct gaze group were presented with a face making eye contact, and participants in the averted gaze group were presented with a face looking downward. In both pronoun-selection tasks, it was expected that participants in the direct gaze group would choose more first-person singular pronouns than participants in the averted gaze group. Like in Experiment 1, we also measured self-reported self-awareness with the Situational Self-Awareness Scale (SSAS; Govern & Marsch, 2001). On the SSAS, the perception of direct gaze was expected to elicit higher ratings of public self-awareness than the perception of averted gaze.

3.1. Method

3.1.1. Participants

The participants were 42 people aged 16–35 years (mean age = 23.7 years, *SD* = 4.2; 35 females). They were recruited from bulletin boards and e-mail lists of the University of Tampere, Tampere University of Applied Sciences, and various upper secondary schools in Tampere. The participants were all native speakers of Finnish with no history of neurological or psychiatric disorders. 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). Written consent was obtained from each participant before the experiment.

3.1.2. Materials

The stimuli were the face of either a male or a female model person. Depending on the group assignment of the participant, the model was either making eye contact or gazing 30° downward. The model maintained a neutral expression on his or her face. The model person did not give any instructions to the participant. The faces were presented through a voltage sensitive liquid crystal (LC) shutter (NSG UMU Products Co) attached to a black panel. The state of the LC shutter (transparent or opaque) was operated by a desktop computer and the LC shutter switched between opaque and transparent states within an overall speed of 3 ms. The LC shutter panel was placed on a table between the participant and the model. A computer screen and a keyboard were placed on the participant's side of the LC shutter. The height of the computer screen was adjusted so that the participant was able to see the entire face of the model, but nothing below his or her chin. Participants were seated at a distance of 80 cm from the computer screen and 100 cm from the LC shutter. The face of the model was at a distance of 30 cm from the LC window. For an illustration of the arrangement, see Fig. 3.

Two pronoun-selection measures of self-referential processing were used. They were presented on the computer screen. The foreign-language task was identical to the one used in Experiment 1 (Davis & Brock, 1975). In addition to that, the Linguistic Implications Form was included in the procedure (LIF; Wegner & Giuliano, 1980, 1983). In the LIF, participants were presented with Finnish sentences, each containing a blank in place of a person pronoun (see Appendix B for an English translation of the task). The task was to choose a pronoun for each blank. On each trial, there were three pronouns to choose from. One pronoun was always first singular, and the two others were either first plural, third singular, or third plural, depending on the sentence context. For each trial, the options were presented in a randomized order. The task included 10 Finnish sentences, most of which were directly translated from the LIF by Wegner and Giuliano (1983). The task included the following types of sentences: *Myyjä yritti taivutella (minua, häntä, meitä) ostamaan sanakirjan* [The salesman tried to persuade (me, her, us) to buy a dictionary] and *Meteli alkoi häiritä (meitä, heitä, minua) ennen pitkää* [The noise got to (us, them, me) before long].

3.1.3. Design and procedure

Participants were randomly assigned to two groups. Participants in the direct gaze group saw the model making eye contact and participants in the averted gaze group saw the model looking downward. For each participant, the model was looking at the same direction at all times. The genders of the models and gaze directions were counterbalanced across participants' gender. The data were collected from one participant at a time.

After arriving to the laboratory, the participant was told that that the experiment will be carried out on a computer and that it includes tasks regarding linguistic perception, which would be later instructed on the computer screen. The partici-

Fig. 3. Illustration of the arrangement in Experiment 2. The participant is looking at the model person through the transparent LC shutter. The computer screen and the keyboard are placed in front of the LC shutter panel.

pant was seated in front of the computer and the LC shutter, and a written consent was obtained. The experimenter demonstrated the participant the functioning of the LC shutter and explained that the model person would be sitting behind the LC shutter and the LC shutter would become transparent on each task trial. The experimenter announced that he or she would be in the next room during the experiment and not observing the participant, and left the room.

Before beginning the tasks, the computer program requested information regarding the participant's age and gender. Then, the program presented the participant with instructions of the foreign-language task (Davis & Brock, 1975). Each trial consisted of the LC shutter becoming transparent for 5 s and one multiple-choice task. When the LC shutter switched back to opaque, the task was immediately presented on the computer screen in front of the LC shutter. After choosing one of the six answer options, there was an inter-stimulus interval (ISI) of 1 s, after which the next trial began. The foreign-language task consisted of 20 trials. After that, the Linguistic Implications Form followed (LIF; Wegner & Giuliano, 1980, 1983). Instructions for the LIF explained that to understand the meaning of a sentence, some words can be redundant, and the intention of the task was to investigate the redundancy of pronouns in sentences. The instructions said that the computer program would present Finnish sentences, each containing a blank, with the assignment of choosing the one from three pronoun options the participant thought would best fit the sentence. The instructions explained that all the options would be grammatically correct, and the participant's task was to choose, and when in doubt, to guess the one that makes most sense to them. Similarly to the foreign-language task, each trial consisted of the LC shutter becoming transparent for 5 s and one multiple-choice task. After choosing one of the options and an ISI of 1 s, the next trial began. The LIF consisted of 10 trials. After the two tasks, the participant completed the Situational Self-Awareness Scale (Govern & Marsch, 2001) and the manipulation check items, exactly like in Experiment 1. Then, the experimenter returned to the laboratory and debriefed the participant. The participant was then thanked and given the participation reward.

3.2. Results

3.2.1. Manipulation checks

All participants correctly perceived whether the model person was looking at them or away from them. On a scale ranging from 1 (strongly disagree) to 7 (strongly agree), most of the participants in the direct gaze group strongly agreed ($M = 6.67$, $SD = 0.66$) with the statement "The model person appeared to be looking at me", whereas most of the participants in the averted gaze group strongly disagreed ($M = 1.24$, $SD = 0.63$) with the statement, $t(40) = 27.41$, $p < 0.001$, $d = 8.42$. Participants reported that they had not understood the foreign languages in the pronoun-selection task. To the statement "I understood the sentences in Swahili", the mean score was 1.40 ($SD = 1.27$), and to the statement "I understood the sentences in Basque", the mean score was 1.21 ($SD = 0.95$).

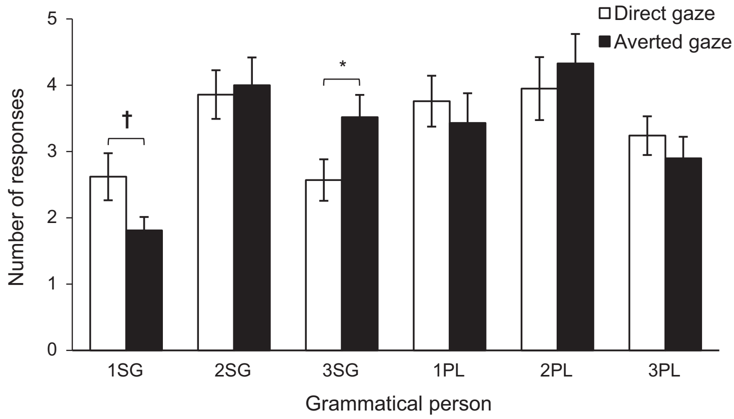

Fig. 4. Mean numbers (and standard errors) of responses in each grammatical person in the foreign-language task by participants in the direct gaze and averted gaze groups, in Experiment 2. Grammatical persons: 1 SG = first singular, 2 SG = second singular, 3 SG = third singular, 1PL = first plural, 2PL = second plural, 3PL = third plural. $^{*}p < 0.05$. † $p < 0.10$.

3.2.2. The foreign-language task

Self-referential processing was measured as the number of first-person singular pronoun responses. A *t* test indicated a trend approaching significance in the number of first-person singular responses between the gaze groups, $t(40) = 1.98$, $p = 0.055$, $d = 0.61$. Consistent with the prediction, the direct gaze group gave more first-person responses ($M = 2.62$, $SD = 1.63$) than the averted gaze group ($M = 1.81$, $SD = 0.93$). The direct gaze group gave less responses in the third-person singular form ($M = 2.57$, $SD = 1.43$) than the averted gaze group ($M = 3.52$, $SD = 1.54$), $t(40) = 2.08$, $p = 0.044$, $d = 0.63$. The use of other grammatical pronouns did not differ between the two groups. The mean number of responses in each grammatical person are shown in Fig. 4.

3.2.3. Linguistic Implications Form

As expected, participants in the direct gaze group gave significantly more first-person responses ($M = 4.48$, $SD = 1.29$) than participants in the averted gaze group ($M = 3.57$, $SD = 1.03$), $t(40) = 2.51$, $p = 0.016$, $d = 0.78$. Also, a trend towards lower use of third-person singular pronouns in the direct gaze group ($M = 1.81$, $SD = 0.98$) than in the averted gaze group ($M = 2.38$, $SD = 0.97$) was observed, $t(40) = 1.90$, $p = 0.065$, $d = 0.58$. The number of responses in other grammatical pronouns did not differ between the two groups (see Fig. 5).

3.2.4. Situational Self-Awareness Scale

Mean scores and standard deviations of the SSAS ratings are presented in Table 1. A *t* test was conducted to compare the SSAS ratings between the two groups. The groups did not differ in their reports of public self-awareness, $t(40) = 0.36$, $p = 0.722$, $d = 0.46$, or private self-awareness, $t(40) = 0.87$, $p = 0.392$, $d = 0.42$. Surprisingly, however, a significant effect of gaze direction on the ratings of awareness of immediate surroundings was found, t(40) = 3.07, $p = 0.004$, $d = 0.94$, with the participants in the averted gaze group ($M = 4.11$, $SD = 1.25$) rating higher levels of awareness of immediate surroundings than participants in the direct gaze group ($M = 3.02$, $SD = 1.06$).

3.3. Discussion

Like in Experiment 1, in Experiment 2, we investigated the effect of another person's gaze direction on self-referential processing. Three modifications were made to the stimuli and the procedure. Live faces were used as stimuli instead of video clips of faces. Self-referential processing was measured with the Linguistic Implications Form (LIF; Wegner & Giuliano, 1980, 1983), in addition to the foreign-language task (Davis & Brock, 1975). Furthermore, in Experiment 2, the data were collected from one participant at a time, whereas in Experiment 1 three to four participants participated simultaneously.

Results showed an increase in the number of first-person singular responses when preceded by eye contact with a live person. In both measures, the direct gaze group gave more first-person responses than the averted gaze group, though in the foreign-language task, the effect was only a trend close to statistical significance. On the SSAS, the participants of the two groups did not differ in their reports of public self-awareness or private self-awareness, but the averted gaze group reported heightened awareness of immediate surroundings. Because no difference in self-referential processing between the direct gaze and averted gaze groups was observed in Experiment 1 using video stimuli, the results of the two experiments together suggest that the enhancement of self-referential processing by the perception of direct gaze is stronger in–or perhaps limited to–genuine eye contact, whereas a mere video clip of direct gaze may not have such an effect.

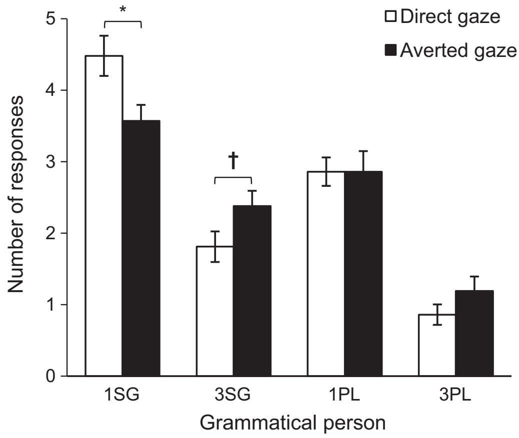

Fig. 5. Mean numbers (and standard errors) of responses in each grammatical person in the Linguistic Implications Form by participants in the direct gaze and averted gaze groups, in Experiment 2. Grammatical persons: 1 SG = first singular, 3 SG = third singular, 1PL = first plural, 3PL = third plural. $^{*}p < 0.05$. $^{\dagger}p < 0.10$.

Table 1
Mean scores and standard deviations on situational self-awareness scale by gaze group.

Gaze group	Public		Private		Surroundings	
	M	*SD*	*M*	*SD*	*M*	*SD*
Direct	3.38	1.74	3.62	1.01	**3.02**	1.06
Averted	2.65	1.38	4.05	1.03	**4.11**	1.25

Note. A statistically significant ($p < 0.05$) difference between the gaze groups is indicated by bolding.

Experiment 2 demonstrated an increase in self-referential processing as a result of eye contact in two linguistic tasks. In the LIF, the effect was statistically significant, whereas in the foreign-language task, only a trend towards the effect was observed. In the discussion of Experiment 1 (Section 2.3), the LIF was speculated to be better able to tap into self-referential processing than the foreign-language task, because the LIF requires the participants to make their pronoun choices based on the interpretation of a comprehensible context. Based on these results, it seems that an implicit task that includes interpretation of context may, indeed, be a better measure of self-referential processing than one where the context is presented in an incomprehensible language.

In the discussion of Experiment 1, the relatively long duration of the used video stimuli (5 s) was brought up as another possible explanation for not finding the effect of gaze direction. In the study by Baltazar et al. (2014), an image of direct gaze presented for 1.5 s was found to enhance interoceptive self-awareness and, hence, the stimulus duration was considered to be a possible explaining difference between their results and the results of Experiment 1. Moreover, after finding, in Experiment 2, that the effect of gaze direction was stronger in the LIF than in the foreign-language task, we decided to run an additional control experiment to investigate whether the effect of gaze direction on self-referential processing could be observed with video stimuli of shorter presentation duration (1 s) and the LIF as a complementary measure. In all other regards the control experiment was identical with Experiment 1. The results showed no difference in the use of first-person pronouns between the direct and averted gaze groups in either of the two tasks.[1] Thus, the results of the control experiment further suggest that only genuine eye contact elicits self-referential processing, whereas a direct gaze in video clips, regardless of their length, does not have an effect on it.

Unexpectedly, the groups did not differ in their reports of public self-awareness. This result conflicts with our previous studies (Hietanen et al., 2008; Myllyneva & Hietanen, 2015; Myllyneva et al., 2015; Pönkänen et al., 2011) that have consistently found an increase in self-reported self-awareness as a result of eye contact with a live person. A likely explanation for

[1] The control experiment included 40 participants (mean age = 23.9 years, $SD = 4.3$; 32 females). All participants passed the manipulation check questions regarding the perception of gaze direction and the comprehension of the languages. Two participants were excluded from the analysis because they guessed what the linguistic tasks were about. The use of first-person singular pronouns did not differ between the two gaze groups in either of the two tasks. In the foreign-language task, the direct gaze group gave an average of 1.47 ($SD = 0.77$) and the averted gaze group an average of 2.05 ($SD = 1.35$) first-person responses, $t(36) = 1.62$, $p = 0.11$, $d = 0.33$. In the LIF, the direct gaze and averted gaze groups gave an average of 4.21 ($SD = 1.18$) and 4.58 ($SD = 1.47$) first-person responses, respectively, $t(36) = 0.34$, $p = 0.40$, $d = 0.28$. The SSAS ratings of public self-awareness, $t(36) = 0.00$, $p = 1.00$, $d = 0.00$; private self-awareness, $t(36) = 0.28$, $p = 0.78$, $d = 0.09$; or awareness of surroundings, $t(36) = 0.61$, $p = 0.66$, $d = 0.15$, did not differ between the two groups.

the differing results stems from the fact that our previous studies used a within-subjects design, whereas the present study used a between-subjects design. It is possible that in a within-subjects design, the participants, probably unintentionally, contrast the two conditions against each other, which may augment the effect of the manipulation and increase the likelihood to observe the effect in the dependent variable.

Participants in the averted gaze group reported higher ratings of awareness of surroundings than participants in the direct gaze group. This was a surprising result and, to our knowledge, no such effect has been observed in previous studies. Conscious attention has been proposed to be a bidirectional phenomenon, directed either to the self or to the external world (Duval & Wicklund, 1972). Enhanced attention to the surroundings observed in the averted gaze group may thus reflect reduced self-focused attention. Conversely, lower attention to the surroundings in the direct gaze group may reflect higher self-focused attention, indicating an increase in self-awareness by eye contact.

4. General discussion

We conducted two experiments to investigate whether eye contact induces self-referential processing. In Experiment 1, video clips of a person with direct or averted gaze were shown to participants followed by a foreign-language pronoun-selection task, an implicit measure of self-awareness proposed to tap into self-referential processing (Davis & Brock, 1975). Participants were randomly assigned to two groups, one group seeing the models gazing directly at them and the other seeing the same models looking downward. Experiment 2 was otherwise similar to Experiment 1, but instead of video stimuli, the participants were facing another live person, and they performed two pronoun-selection tasks: the same foreign-language task as in Experiment 1 and the Linguistic Implications Form (Wegner & Giuliano, 1980, 1983). In both experiments, the main hypothesis was that participants in the direct gaze group would give more first-person responses in the pronoun-selection tasks than participants in the averted gaze group. An increase in self-referential processing by eye contact was observed in Experiment 2 but not in Experiment 1. The most probable explanation for the differing results has to do with the use of live faces instead of video clips of faces as stimuli in Experiment 2. Taken together, the results tentatively suggest that only genuine eye contact with a live person induces self-referential processing, whereas watching videos of a person making eye contact does not. In addition to the implicit measures, explicit public and private self-awareness were measured with the Situational Self-Awareness Scale (SSAS; Govern & Marsch, 2001). The gaze direction, however, did not have an effect on these explicit measurements in either of the experiments.

The findings complement the picture of the self-awareness effect of eye contact. Self-referential processing is a key feature of self-awareness, and as far as we know, this is the first study to directly demonstrate that eye contact increases self-referential processing of incoming information. Previously, eye contact has been demonstrated to enhance self-awareness measured as heightened self-reported awareness of one's appearance (Hietanen et al., 2008; Myllyneva et al., 2015; Pönkänen et al., 2011) and as an enhancement of interoceptive self-awareness (Baltazar et al., 2014). The present results also further the knowledge regarding the use of pronoun-selection tasks in the measurement of self-awareness. The pronoun-selection measures have been found to be sensitive to various manipulations, such as being in front of a television camera or a mirror (Davis & Brock, 1975), writing about oneself (Silvia & Eichstaedt, 2004), running in place (Wegner & Giuliano, 1983), imagining a happy event happening to oneself (Silvia & Abele, 2002), or perceiving a self-related figure in a central position among other figures (Snow et al., 2004). However, they have not been used with manipulations that include the direct observation of another individual. The present study introduces a new manipulation that affects the performance in pronoun-selection-based measures of self-awareness.

The implicit measures of the present study were based on the use of first-person pronouns, an increase in which was proposed to reflect enhanced self-referential processing. In the foreign-language task, participants were asked to guess a translation for an incomprehensible pronoun, and in the LIF, to fill in the blank in a sentence with the best-fitting pronoun. In both tasks, participants were asked to choose between pronoun options, one of which was always first-person singular and thus referring to the self. Davis and Brock (1975), who devised the foreign-language task, proposed that the number of self-referring responses should reflect the direction of one's attention in such a way that self-focused attention would lead to an increase in self-reference. They examined this by turning participants' attention upon themselves in a forthright way—by presenting them with their own image in a mirror—and found the use of self-referring pronouns to increase. However, Davis and Brock did not speculate on the mediating mechanisms between self-focused attention and self-referring responses. We propose enhanced self-referential processing to be such a mediator. Enhanced self-referential processing is central to self-awareness (Hull & Levy, 1979), and it is also associated with an increased accessibility of self-concept (Hull et al., 1988). The pronoun-selection tasks have been suggested to measure the accessibility of self-related cognitions, and indeed, the prevalence of self-related thoughts is associated with the use of first-person pronouns (Wisman et al., 2015). We propose that the activation of self-referential processing results in an enhanced accessibility of self-related cognitions and this, in turn, biases the perception of intrinsically neutral sentences as self-referring and leads to an increase in the use of self-referring pronouns. As noted in the general introduction, Conty et al. (2016) recently proposed that eye contact elicits self-referential processing. The present results give empirical support to their proposition and complement the knowledge of the effects of eye contact on cognition.

Self-referential processing was found to be increased only by genuine eye contact with a live person, and not by perception of a model with straightforward gaze appearing on a video. The results from an additional control experiment described in the discussion of Experiment 2 (Section 3.3) confirmed that the lack of gaze direction effect when using video stimuli was not related to the presentation time of the stimuli. Collectively, the results of the experiments suggest that, for self-referential processing to increase, the perception of direct gaze may need to be accompanied by the experience of being watched by another person (cf. Conty et al., 2016). This interpretation is in alignment with our previous studies that found an increase in self-reported self-awareness only when participants were facing a live person, and not when looking at an image on a computer screen (Hietanen et al., 2008; Pönkänen et al., 2011), or when the live person was presented through an alleged one-way mirror and the participants were led to believe that the other person could not see them (Myllyneva & Hietanen, 2015).

The difference between the two experiments can also be conceptualized as a presence or absence of interaction between the participant and the model. With a video stimulus, obviously, no reciprocal interaction can occur. In contrast, with a live model, even though no conversation took place and the model person was instructed to stay expressionless and motionless, the participant and the model both knew that they were looking at each other mutually and, thus, that each was able to react to the other's behavior. Also, it is inevitable that limited transmission of subtle nonverbal information (e.g., blinks, cues of breathing etc.) occurred between the two. In this regard, the results lend support to the 'second-person' argument of social cognition. According to this argument, social cognition is fundamentally different when one is in interaction with another as compared to sheer observation of interaction between other people. Indeed, a growing number of studies indicate that being involved in social interaction has effects on cognition, as observed in both behavior and neural activity (for a review, see Schilbach et al., 2013). As self-referential processing was enhanced only by genuine eye contact, our results suggest that non-verbal social interaction occurring in eye contact may trigger self-referential processing, and this does not happen with the perception of direct gaze in the absence of an interaction.

Importantly, however, the present study does not compellingly demonstrate that only genuine eye contact induces self-referential processing, whereas an image of a direct gaze does not. The main aim of the study was to examine whether the perception of direct gaze elicits self-referential processing, not to compare different presentation forms of direct gaze against one another. Due to this reason, a direct comparison of live and video gaze was not carried out within a single experiment. As the results were obtained in separate experiments with slightly different test conditions, they cannot be directly compared. Further research examining the effect of different presentation forms of direct gaze on self-referential processing is therefore needed.

Interestingly, imaging studies investigating the activation elicited by eye contact and studies investigating the activation during self-referential processing have both reported increased activation in at least one common area of the brain, the medial prefrontal cortex (mPFC) (Kampe, Frith, & Frith, 2003; Northoff et al., 2006; Senju & Johnson, 2009). The area is associated with theory of mind processes. Studies on processing of direct gaze have indicated that direct gaze is first detected by a fast subcortical route followed by projections to various regions on the cortex (Senju & Johnson, 2009). One of the first cortical areas to be activated by direct gaze is the mPFC (Conty, N'Diaye, Tijus, & George, 2007). In the mPFC, the dissociation between direct and averted gaze processing occurs as soon as 160 ms after the presentation of the gaze stimuli. Imaging studies suggest that the mPFC is also implicated in self-referential processing (Fossati et al., 2003; Schilbach et al., 2006). In a study examining the self-referential processing of emotional words, the more dorsal part of the right medial prefrontal cortex (dmPFC) was found to be the main area mediating self-reference (Fossati et al., 2003). The increase of activation in the right dmPFC was observed only when the words were processed in reference to the self, and it was present irrespective of the valence of the words. In another study, the right dmPFC was found to activate differentially when participants were presented with a virtual character gazing at them directly in comparison to the same character with an averted gaze (Schilbach et al., 2006). The authors suggested that the dmPFC activation during eye contact reflects the detection of the self-reference of the perceived gaze. The present results converge with the imaging evidence and provide direct evidence that self-referential processing is induced by the perception of eye contact.

Of the two pronoun-selection task, the Linguistic Implications Form may be more sensitive to the self-awareness manipulation. In Experiment 2, a significant effect of gaze direction on the use of first-person pronouns was found for the LIF, whereas for the foreign-language task, only a trend towards the effect was observed. The results suggest that a pronoun-selection task that includes an interpretation of context may be a better measure of self-awareness than one where the pronoun choices are made regarding an incomprehensible context. Interestingly, in both tasks, the number of third-person singular responses was lower for the direct gaze group than for the averted gaze group. In the LIF, the number of third-person responses was actually found to negatively correlate with the number of first-person responses, $r(40) = -0.686$, $p < 0.001$. In a pronoun-selection task where one understands the sentences, the tendency to perceive and choose first-person pronouns seems to come specifically at the expense of the use of third-person pronouns. This suggests that in future research a decrease in the use of third-person responses or an increase in the ratio of first-person to third-person responses may possibly be used as measures of self-referential processing or self-awareness more generally.

In addition to the implicit measures, self-awareness was assessed with a self-report measure. For this purpose, the Situational Self-Awareness Scale was used (SSAS; Govern & Marsch, 2001). The SSAS measures awareness of the public side of the self (of one's appearance), awareness of the private side of the self (of one's thoughts and feelings), and awareness of one's surroundings. The participants in the direct gaze group were expected to rate their level of public self-awareness higher than the participants in the averted gaze group. However, no increase in self-reported self-awareness by eye contact was found in either of the two experiments. In the discussion of Experiment 2 (Section 3.3), this finding was proposed to result from the use of a between-subjects design. Previous studies (Hietanen et al., 2008; Myllyneva & Hietanen, 2015;

Myllyneva et al., 2015; Pönkänen et al., 2011) demonstrating the effect employed a within-subjects design. In a within-subjects design, the participants can contrast the direct gaze image against the direct gaze of a live person, which may augment the perceived difference between the two. The present results also imply that, in comparison to self-reports, implicit methods may be more sensitive measures of self-awareness.

Unexpectedly, in Experiment 2, the direct gaze group rated their awareness of immediate surroundings considerably lower than the averted gaze group. Based on the idea of attention as a bidirectional phenomenon (Duval & Wicklund, 1972), lower attention to the surroundings in the direct gaze group than in the averted gaze group may reflect higher self-focused attention. In the development of the Situational Self-Awareness Scale, the scale of awareness of immediate surroundings was included as a measure of "non-self-focus" (Govern & Marsch, 2001, p. 368). Govern and Marsch argued that when attention is not directed to one's self, it is usually directed to something else, such as the physical surroundings. They reasoned that including items that measure this non-self-focus would be a useful property for a measure of self-awareness. Coming from this perspective, the direct gaze group's lowered ratings on a scale of non-self-focus support the hypothesis of eye contact increasing self-awareness.

In future studies, it would be interesting to investigate the interplay of personal characteristics of the counterparts and the self-awareness effect of eye contact. For example, it has been found that the cognitive functioning of men (but not of women) is impaired by a mixed-sex interaction due to increased impression management, same-sex interactions having no such effect on either gender (Karremans, Verwijmeren, Pronk, & Reitsma, 2009). The increased attempt of men to control women's impression of themselves may be associated with increased self-focus and enhanced self-awareness. Impression motivation has also been shown to increase when one interacts with someone who is attractive, likable, or has a high status (Schlenker, 1980), all attributes which may potentially induce self-awareness in another. Moreover, as Conty et al. (2016) proposed that personal characteristics of the perceiver, such as anxiety, cultural background and gender, may modulate the effect that another's direct gaze has on them, it would be important to examine the influence of these characteristics on the effect of eye contact on self-awareness.

5. Conclusions

Eye contact was found to increase self-referential processing, a key feature of self-awareness. As far as the authors know, this is the first study to directly demonstrate that eye contact increases self-referential processing of incoming information. The results from the present experiments suggest that the effect is stronger in, and perhaps limited to, eye contact with a live person in comparison to the mere perception of a direct gaze image. The effect of eye contact was only observed with the implicit methods, and no increase in explicit self-awareness was seen in the self-report ratings. This indicates that implicit methods may be more sensitive in the measurement of self-awareness compared to self-report methods.

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Appendix A. Foreign-language task (English translation)

In the following task, sentences in foreign languages are presented. The task is to guess which Finnish [English] word corresponds to the underlined word. The underlined words are person pronouns. Choose the one of the six different alternatives you suppose to correspond to the underlined word.

The sentence task investigates linguistic intuition. Thus, the purpose is not to deduce the correct answer from the structure of the sentence or the target words, but to intuitively guess the possibly correct alternative.

1. Bibi anasoma kitabu. (I, you, he/she, we, you, they)
2. Nakaa na dada yangu. (my, your, his/her, our, your, their)
3. Yeye ancheza mpira wa kikapu ingawa ni mfupi. (I, you, he/she, we, you, they)
4. Atakwenda kwa kaka yake. (my, your, his/her, our, your, their)
5. Ninyi hamli nyama. (I, you, he/she, we, you, they)
6. Ulipikia chakula kwa sisi. (me, you, him/her, us, you, them)
7. Labda wao watarudi mwaka keshoi. (I, you, he/she, we, you, they)
8. Wale ni wakulima na hawa ni wapagazi. (I, you, he/she, we, you, they)
9. Nitakuazima kila kitu ila gari langu. (my, your, his/her, our, your, their)
10. Yule bwana alikunywa bia hii. (I, you, he/she, we, you, they)
11. Gero lanera joan da. (I, you, he/she, we, you, they)

12. Bihar zure etxetik pasa behar dut. (my, your, his/her, our, your, their)
13. Gu fruta saltzen ari gara. (I, you, he/she, we, you, they)
14. Zuei arropa berriak gustatzen zaizkizue. (my, your, his/her, our, your, their)
15. Sei t'erdietako autobusean joango gara. (I, you, he/she, we, you, they)
16. Zuk nere lagunak ezagutzen dituzu. (I, you, he/she, we, you, they)
17. Haiek lore asko dituzte. (I have, you have, he/she has, we have, you have, they have)
18. Orain hona etorri naiz bizitzera. (I, you, he/she, we, you, they)
19. Gure haurrak ez dira etorriko. (my, your, his/her, our, your, their)
20. Ez zuen alde egingo. (I, you, he/she, we, you, they)

Appendix B. Linguistic Implications Form (English translation)

In the psychological research of language, it has been found that many single words are redundant for the meaning of the whole sentence. In this task, the significance of pronouns for the comprehension of a sentence is examined.

Finnish [English] sentences from various situations are presented in the task. In each sentence, one pronoun is replaced with a blank. In each task there are three alternatives, all of which fit the sentence grammatically. The task is to choose from the alternatives the pronoun that you think would most probably fit the context. Choose the pronoun that makes most sense to you. If you are uncertain of the answer, you can guess.

1. Myyjä yritti taivutella _______ ostamaan sanakirjan. (minua, häntä, meitä)
The salesman tried to persuade _______ to buy a dictionary. (me, her, us)
2. Meteli alkoi häiritä _____ ennen pitkää. (meitä, heitä, minua)
The noise got to _______ before long. (us, them, me)
3. Älä puhu _______ noin, se ei ole reilua. (hänelle, meille, minulle)
Don't speak to _______ like that, it is not fair. (him, us, me)
4. Kaikki saivat hylätyn kokeesta, paitsi _______. (minä, me, hän)
Everyone failed the test, except for _______. (me, us, her)
5. _______ meni niin paljon aikaa suunnitteluun, että työ ei valmistunut ajoissa.
(heillä, meillä, minulla)
_______ spent so much time planning that the work was not finished in time. (they, we, I)
6. Rankkasade kasteli _______ kauttaaltaan. (heidät, minut, hänet)
Rainstorm soaked _______ through. (them, me, him)
7. Joku pysäytti _______ kysyäkseen reittiä stadionille. (heidät, minut, meidät)
Someone stopped _______ to ask for directions to the stadium. (them, me, us)
8. Kassavirkailija velotti _______ liian vähän ostoksista. (häneltä, meiltä, minulta)
The cashier charged _______ too little for the groceries. (her, us, me)
9. Hyttyset eivät edes häirinneet _______. (häntä, meitä, minua)
The mosquitoes didn't even bother _______. (him, us, me)
10. Päivällinen odotti _______ pöydässä. (häntä, minua, meitä)
Dinner was waiting for _______ on the table. (him, me, us)

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

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

Jonne O. Hietanen | **Mikko J. Peltola** | **Jari K. Hietanen**

Human Information Processing Laboratory, Faculty of Social Sciences/Psychology, Tampere University, Tampere, Finland

Correspondence
Jari K. Hietanen, Human Information Processing Laboratory, Faculty of Social Sciences/Psychology, FI-33014 Tampere University, Tampere, Finland.
Email: jari.hietanen@tuni.fi

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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).

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.

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–β = .80, α = .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 (η^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

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.

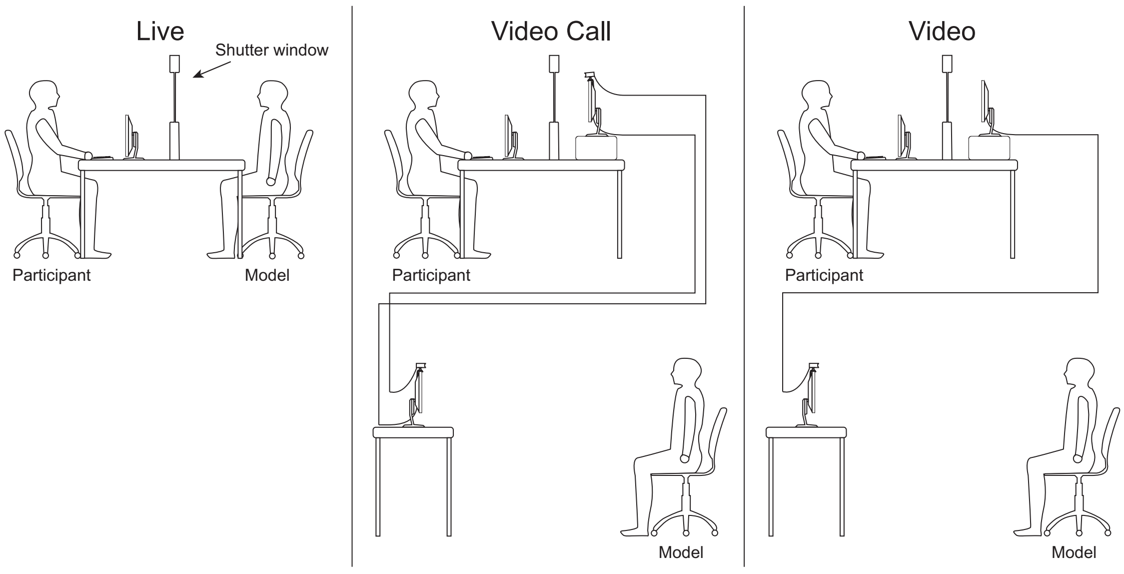

FIGURE 2 An illustration of the experimental setup in the three conditions. In the video call and video conditions, the model person was in another room and his or her image was portrayed in real time with a zoomed-in web camera. The distances are not in exact scale

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.

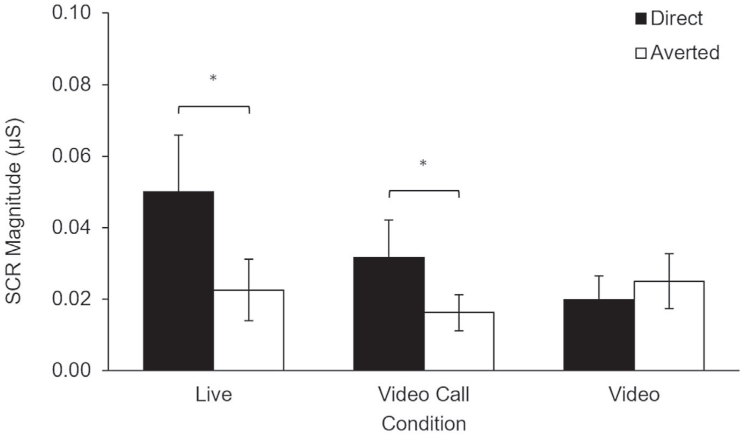

FIGURE 3 SCR magnitudes and standard errors of the mean (*SEM*) in response to direct and averted gaze within each condition.
*$p < .05$, two-tailed t test

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 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.

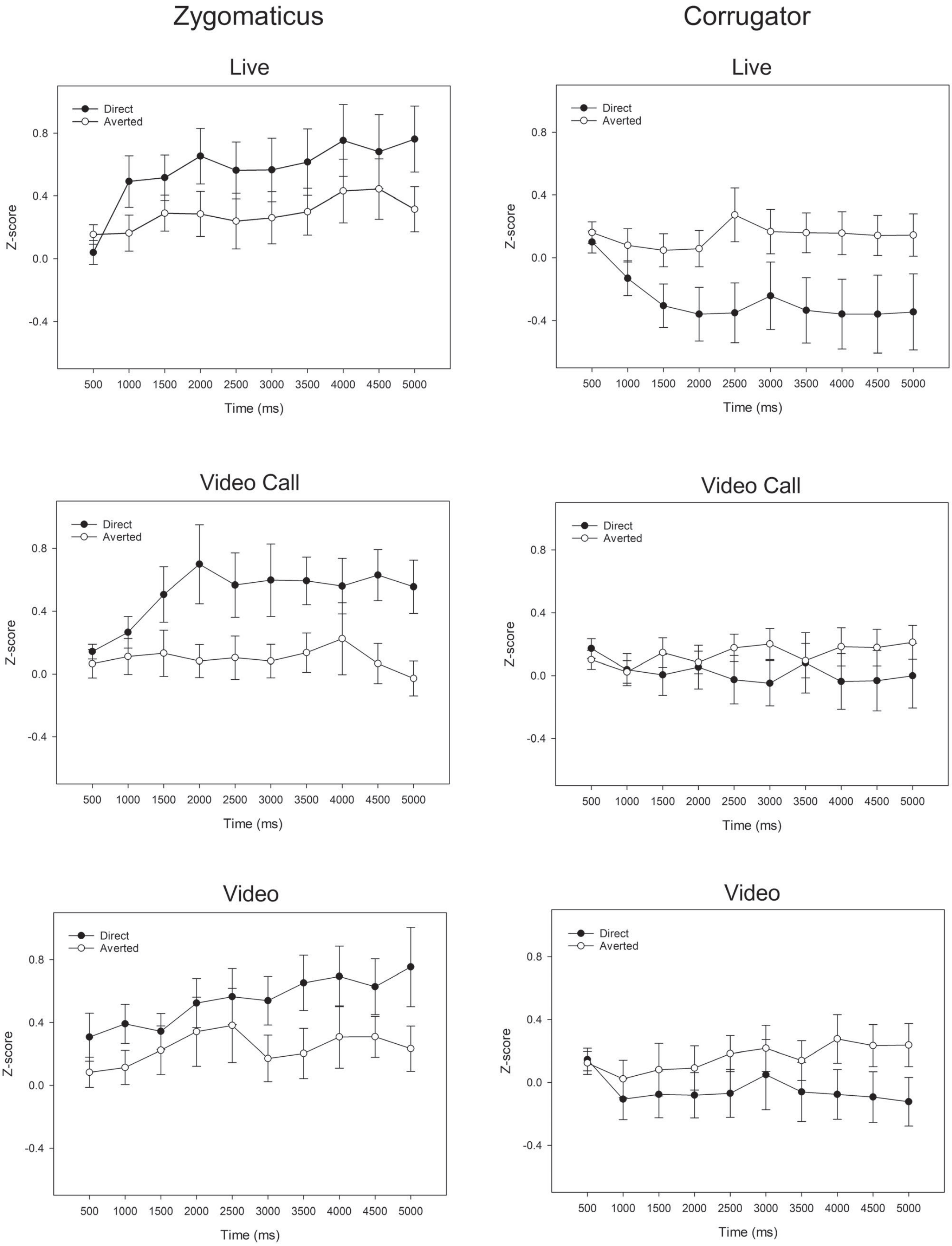

FIGURE 4 Standardized mean zygomatic and corrugator EMG responses (and *SEM*) in response to direct and averted gaze within each condition

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 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.

ORCID

Jonne O. Hietanen https://orcid.org/0000-0001-5705-6791
Mikko J. Peltola https://orcid.org/0000-0001-9993-9963
Jari K. Hietanen https://orcid.org/0000-0002-7585-3775

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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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III

Eye contact reduces lying

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Eye contact reduces lying

Jonne O. Hietanen, Aleksi H. Syrjämäki, Patrick K. Zilliacus, Jari K. Hietanen*

Human Information Processing Laboratory, Faculty of Social Sciences/Psychology, Tampere University, Tampere FI-33014, Finland

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ABSTRACT

The perception of watching eyes has been found to reduce dishonest behavior. This effect, however, has only been shown in situations where it can be explained by increased adherence to rules and norms, and thus a watching-eyes effect on dishonesty per se has not been demonstrated. Moreover, the effect has been investigated only with images of watching eyes, not in an interactive situation with a live person, which may arguably have different effects on behavior. In the present study, the effect of watching eyes on dishonesty was investigated with an interactive computer game of lying. Participants played the game against a confederate, whom they believed to be another participant. On each trial, they were briefly presented with a view of the confederate, after which they chose whether to lie in the game. The confederate alternated between the use of direct and downward gaze. The results showed that another individual's direct gaze reduced lying in the game. The findings have implications for both everyday and professional situations, such as clinical conversations and police interrogations.

1. Introduction

The perception of another individual's direct gaze is known to influence many aspects of human emotion, cognition, and behavior (for reviews, see Conty, George, & Hietanen, 2016; Hietanen, 2018; Kleinke, 1986; Senju & Johnson, 2009). Among other effects, another's direct gaze has been demonstrated to increase honest and prosocial behavior. People seem to care about others' opinion of themselves and, in situations where they are being observed by others, they behave in a more socially desirable way (Oda, Niwa, Honma, & Hiraishi, 2011). Interestingly, even a mere image of watching eyes seems to act as a reminder of such evaluative observance and hence increase positive behavior. Studies have demonstrated eye images to increase prosocial behavior, such as helping of others (Manesi, Van Lange, & Pollet, 2016) and giving money to charities (Powell, Roberts, & Nettle, 2012), and reduce many forms of undesirable behaviors, ranging from minor mischief, like taking drinks without paying (Bateson, Nettle, & Roberts, 2006), to more serious dishonesty, such as stealing bicycles (Nettle, Nott, & Bateson, 2012).

Some researchers have explained the observed results by an increased tendency for prosocial behavior, whereas others suggest that increased adherence to norms may better explain the effects. For example, in an economic game paradigm, a robust increase in the likelihood of donating money by presenting participants with a schematic drawing of watching eyes has been repeatedly demonstrated (for a review, see Nettle et al., 2013). Importantly, however, in most of these studies, the perception of watching eyes has not been found to increase the overall amount of donations, but only the probability of donating. Nettle et al. (2013) explained this as a heightened awareness of norms and increased normative behavior by the perception of others' observance, as in such economic games, donating something, but not excessively, is likely perceived as the norm. However, not all results fit this interpretation. In one study, for example, an eye image was found to increase non-normative generosity (charitable donations that were uncommon and not

* Corresponding author.
E-mail address: jari.hietanen@uta.fi (J.K. Hietanen).

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socially obligated) suggesting an increase in prosocial behavior in and of itself (Powell et al., 2012).

In an inventive study, Oda, Kato, and Hiraishi (2015) examined prosocial lying and norm adherence and found watching eyes to increase norm adherence and honesty at the cost of prosocial behavior. In the experiment, participants rolled a die under a paper cup, checked the rolled number privately through a hole in the cup, multiplied the number by a certain amount of yen, and reported it on a sheet of paper. The experimenters promised to give a corresponding amount of money to charity. Therefore, in this setting, by lying and breaking the rules participants were able to give more to charity and thus act more prosocially. The results showed that, without an image of watching eyes, participants tended to lie and report the numbers as higher than was statistically expected, but in the presence of watching eyes, the numbers were reported honestly. This suggests that the primary behavioral effect of watching eyes is an increase in honesty and norm adherence, and it occurs even at the expense of prosociality. Notably though, in this study and others, which have shown a watching-eyes effect on dishonesty (Bateson et al., 2006; Nettle et al., 2012), the observed effect can be fully explained by increased norm adherence. Dishonesty, however, is not always against prevailing rules or social norms. This may be the case, for example, in telling “white lies” or in playing certain games, like poker, where bluffing is an integral part of the game. To our knowledge, no study has examined the effect in a setting where the measured form of dishonesty is not also a clear rule infringement. Therefore, a reduction in dishonesty per se by the perception of watching eyes remains to be demonstrated.

Overall, studies examining the watching-eyes effect on dishonesty are few and there is discrepancy in their results. In one study, the effect was scrutinized in three different experiments that each offered a possibility for economic or social gain by cheating (Cai, Huang, Wu, & Kou, 2015). In none of the different settings did the image of watching eyes reduce the amount of cheating by participants. The authors attributed the observed null effect to the clear anonymity of the situations (the experiments were conducted in separate cubicles and all materials were anonymous), which may have reduced the salience of reputational concerns. The finding was argued to imply that an eye image does not activate one’s moral standards of honesty, and it only alters behavior in situations where others’ opinion of oneself may be affected. Similarly, in the studies on the watching-eyes effect on prosocial behavior and cooperation, there have been inconsistent results, with some researchers failing to find any effect (Carbon & Hesslinger, 2011; Fehr & Schneider, 2010). It seems that further research on the behavioral effects of watching eyes is indicated.

To our knowledge, the effect of another’s gaze direction on actual lying in an interaction between two people has not been previously studied. This is rather surprising, as one’s own gaze behavior when lying to others has been extensively studied (e.g., DePaulo et al., 2003). Although the effect of perceived direct gaze on dishonest behavior has been previously investigated, as described above, lying directly to another person is in many ways different than the earlier mentioned forms of dishonesty, and we do not know if perceiving another person’s direct gaze reduces lying to him or her. In direct lying, the receiving end of the dishonesty is much more salient and clearly defined compared to a vague idea of a possible sufferer. Knowing who the recipient is has been shown to reduce subsequent lying to them (Van Zant & Kray, 2014). In an interactive situation, the recipient is also able to express doubts, which may further reduce the inclination for dishonesty. In studies on interaction media richness and deception, people have been found to lie more in a video-based interaction than in a face-to-face interaction, and even more in a text-based interaction (Rockmann & Northcraft, 2008; Zimbler & Feldman, 2011). An experiment that involves an interaction between two people also allows the use of genuine eye contact with a live person as a stimulus instead of an image of watching eyes. As described earlier, most previous studies on the effect have used eye images. Studies have shown that viewing a real person evokes different subjective and neurocognitive reactions in the perceiver than a mere image (Hietanen, Leppänen, Peltola, Linna-aho, & Ruuhiala, 2008; Pönkänen, Alhoniemi, Leppänen, & Hietanen, 2010; Pönkänen, Peltola, & Hietanen, 2011). Therefore, a live person could be expected to have different, probably stronger, effects on one’s subjective experience and behavior than a watching-eyes image. Another limitation of most previous studies is that they have compared a photo or a schematic picture of watching eyes to a completely different kind of image, such as a picture of flowers (e.g., Bateson et al., 2006). Despite this, the effect has been attributed to watching eyes and not the mere perception of an eye or a face stimulus, which remains a plausible interpretation of the results. Notably though, in one study that avoided this pitfall, an image of a direct gaze was found to increase prosocial behavior (helping of others) as compared to images of an averted gaze, closed eyes, or flowers (Manesi et al., 2016).

In the present study, the effect of eye contact on lying was investigated by using an interactive computer game of lying and catching another’s lie. In the rules of the game, lying was acceptable and thus reduced lying could not be attributed to increased adherence to norms. Participants played the game against a confederate opponent, whom they believed to be another participant. Participants were led to believe that the study was focusing on physiological responses to the game. On each game trial, they were briefly presented with a view of the opponent through a smart glass window, after which they reported to the opponent the color of a circle appearing on the computer screen. Participants were able to lie about the color in order to earn more points in the game. The opponent alternated between the use of direct and downward gaze in a pseudorandomized order. Lying was expected to be less likely on trials where the opponents directed their gaze towards the participants’ eyes instead of gazing downward.

After the game, participants were asked to complete self-report questionnaires. The watching-eyes effect has been attributed to an automatically-triggered feeling of being the target of another’s observation, which implies heightened self-awareness (Bateson et al., 2006). Arguably, this awareness of an outer perspective on one’s self could then induce favorable changes in behavior, though studies have not examined whether it mediates the effects. In accordance with the idea, however, it has been shown that another individual’s direct gaze may increase public self-awareness (Myllyneva & Hietanen, 2015; Myllyneva, Ranta, & Hietanen, 2015) and that heightened self-awareness is associated with increased honest and prosocial behavior (Beaman, Klentz, Diener, & Svanum, 1979; Diener & Wallbom, 1976; Vallacher & Solodky, 1979; van Bommel, van Prooijen, Elffers, & Van Lange, 2012). Thus, in the present study, we also measured self-awareness with a self-report scale in both gaze conditions. Heightened public self-awareness was expected in response to another’s direct gaze. The effect of watching eyes on lying was expected to be mediated by heightened public self-awareness. In addition, to examine the generalizability of lying in the game to lying in everyday life, participants completed a self-report scale of lying in the past 24 hours. A positive correlation between lying in the game and reported lying in the past day was expected.

2. Method

2.1. Participants

Participants were 51 people aged 19–37 years ($M = 24.7$ years, $SD = 4.1$, 26 females, 25 males) recruited from email lists of the University of Tampere and Tampere University of Applied Sciences. This sample size exceeded Cohen's (1992) recommendation for finding a moderate effect at 0.80 power ($\alpha = 0.05$). The participants were all native speakers of Finnish with no reported history of neurological or psychiatric disorders. In recruitment, participants were told that they would be rewarded with a movie ticket or course credit, but if they win the game, they would be given another movie ticket. However, as the opponent in the game was not a real participant, every participant was rewarded with the extra ticket in addition to the participation reward.

Five participants were excluded from the lying data analysis. Two participants (one female, one male) were excluded due to technical problems in the experimental procedure. Two female participants were excluded for suspicion of the confederate not being another participant. One male was excluded from the analysis due to not lying at all. Additionally, one female was excluded from the Lying Frequency Questionnaire analysis due to a technical error, which occurred in the beginning of the questionnaire.

The research protocol was approved by the Ethics Committee of the Tampere region. All participants gave their written informed consent.

3. Materials and procedure

The experiment consisted of three sections: preparations, lying game, and questionnaires. The entire experiment lasted approximately one hour. Each participant arrived in the laboratory at the same time with a confederate of the same sex. Participants were led to believe that the confederate was another participant. During the whole experiment, the confederate behaved like another participant and the experimenter treated the participant and the confederate alike. A male experimenter welcomed the two and told them that the experiment would be carried out on computers on which an interactive game would be played. He told that the study investigates physiological reactions and for that reason two electrodes were to be connected to the fingers of one player at a time. A written consent was obtained from the participant and the confederate.

After flipping a coin, the experimenter named the participant as player number one and the confederate as player number two and guided them to seats on the opposite sides of a black panel separating the room in two. A voltage-sensitive liquid–crystal (LC) shutter window (NSG UMU Products Co., Ltd., Ichihara, Chiba, Japan) measuring 21.5 cm × 38 cm was attached to the panel. The state of the LC window (transparent or opaque) was operated by E-Prime 2.0 software (Psychology Software Tools, Inc., Pittsburgh, PA, USA) running on a desktop computer, and at first it was set to opaque. The participant and the confederate were seated face to face on opposite sides of the LC window. They both had a 19-inch computer screen and a keyboard positioned on a table in front of them. The heights of the computer screens were such that the players were easily able to see each other over the screens when the window was transparent. Participant was seated at a distance of 70 cm from the computer screen and 80 cm from the LC window. The face of the confederate was at a distance of 70 cm from the LC window and 150 cm from the participant. After the participant and the confederate were seated, the experimenter demonstrated the function of the LC window by opening it (making it transparent) for a moment with the press of a keyboard key. Participant's and confederate's seat heights were adjusted so that they had their eyes on the same level.

The experimenter said that, in the game, player one (i.e., the participant) would be collecting points first and the physiological measurements would be taken first from him or her. He then attached two skin conductance response electrodes (Ag/AgCl) coated with isotonic paste to the palmar surface of the medial phalanges of the index and middle fingers on the participant's left hand. The physiological measurements were carried out only to draw participants' attention away from the actual research question, and for this reason, the skin conductance response data were not analyzed. Moreover, due to the trials having many successive and overlapping brief events (e.g., animation, sounds, and other stimuli), a reliable analysis of skin conductance responses to gaze directions or other events in the game would not have been possible.

Before the game started, the players were both shown a detailed video explaining the instructions and the scoring rules of the game and demonstrating them in game situations. Lying was explicitly allowed in the instructions ("In order to gain more points, you can at times lie about the color"). After the video, the possibility to lie was further emphasized ("If you want, you can lie that the blue circle had been red") along with a summary of all the scoring rules (e.g., "If you report that the circle was red, you will gain 1 point" and "If the opponent checks the color and catches you in a lie, you will lose 5 points"). The experimenter verified that the players had understood the rules. He then announced that during the game he would be seated behind a curtain in a separate part of the room and not be able to observe the participants, after which he left, and the players began the game.

In the beginning of each trial of the game, the LC window turned transparent and the confederate's face was presented against a black background for 4400 ms. The confederate maintained a neutral facial expression. In half of the trials, the confederate was gazing at the participant's eyes (direct gaze), and in the other half, 20° downward with a slight tilt of the head toward the computer screen on his or her side of the panel (averted gaze). In order to appear natural, on the direct gaze trials, the confederate raised his or her gaze from the computer screen toward the participant shortly (in less than one second) after the LC window had turned transparent. The direct and averted gaze trials were presented in a pseudorandomized order. The confederate received instructions on

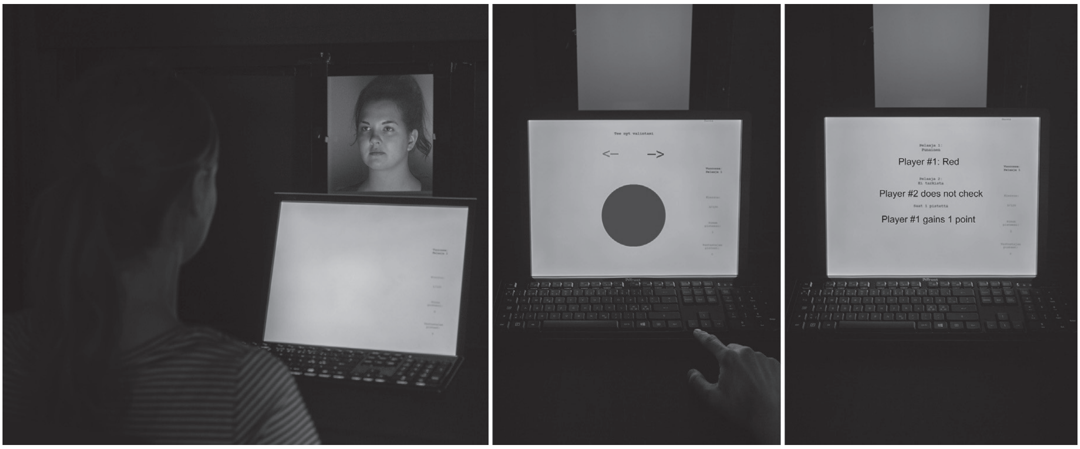

Fig. 1. An example of a trial sequence. The participant first saw the confederate opponent through the transparent LC window. Then, the window turned opaque and the participant was presented with a red or a blue circle. The participant decided which color to report to the opponent, who then decided whether he or she believed it. Finally, the scores were updated based on the decision of the opponent. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

the gaze condition order on the computer screen on his or her side of the LC window.

The lying game was adapted from a study by Karton, Palu, Jõks, and Bachmann (2014) and run on E-Prime 2.0 software. It was presented on the computer screen in front of the participant. As said, each trial started with the presentation of a view of the confederate through the LC window for 4400 ms. After 2400 ms from the onset of the face stimulus, a two-second animation began on the computer screen. In the animation, pictures of a red and a blue circle alternated rapidly. The animation was presented simultaneously with the view of the confederate. Then the window turned opaque, the animation stopped, and participants were shown either a red or a blue circle on the computer screen. They were asked to report the color of the circle to the confederate by pressing left arrow (for red) or right arrow (for blue) keys on the keyboard. The confederate's response to the reported color (whether he or she wanted to see what the color had actually been) was then shown as a text "Player #2 checks" or "Player #2 does not check" on the computer screen. Participants gained 1 point by reporting the color to be red, no points by reporting blue, and lost 5 points if caught lying. The confederate lost 3 points if he or she checked the color and participant had reported it honestly. Participants were led to believe that the confederate made their moves in the game independently, but in actuality, the confederate's moves had been written into the computer program. See Fig. 1 for an example of a trial sequence. The game consisted of 120 trials, 60 with each color. The game scores of the participant and the confederate and the trial number were presented on the right side of the computer screen.

Participants' reports of the colors were checked 12 times (6 times in both gaze conditions), but only when they had reported the color honestly. Participants had to be checked and caught lying an equal number of times in both gaze conditions to avoid biasing them into thinking that the risk of being caught were higher after either gaze direction. They were not caught lying even once because this enabled each participant to be caught lying for the same number of times and equally in both gaze conditions without the exclusion of participants. Even a minimum limit of two lies in each gaze condition (with either of the lies being checked) could have led to the exclusion of many participants due to too few lies in either condition. Moreover, being caught (especially if it happened already on the first lies) was presumed to increase the probability of participants restraining from lying altogether, which would have been antithetical to the aim of the study.

After playing 120 trials, the game ended, and questionnaires (control questions, Situational Self-Awareness Scale, and Lying Frequency Questionnaire) followed. Participants were not yet informed that the game had finished but were led to believe that after the questionnaires, the roles in the game would switch and it would be the confederate's turn to collect points. The confederate's turn to collect points, however, was not played, as it was insignificant for the research question.

Participants were first presented with a control question: "How often do you estimate the opponent was looking at you when the window opened and you saw the opponent?" The question was answered with a number ranging from 0 to 100 percent. The aim of the control question was to exclude participants who had not noticed variation in the gaze direction of the confederate (due to, for example, avoiding looking at him or her), thus responding 0 or 100 percent.

Participants then completed the Situational Self-Awareness Scale (SSAS; Govern & Marsch, 2001) in response to both gaze directions. The window was opened two additional times, and participants filled in the questionnaire after each view of the confederate. The SSAS measures three forms of situational awareness: public self-awareness (measured with items such as "Right now, I am concerned about the way I present myself"), private self-awareness (e.g., "Right now, I am conscious of my inner feelings"), and awareness of immediate surroundings (e.g., "Right now, I am keenly aware of everything in my environment"). Each of the subscales were measured with three items that were answered on a 7-point Likert scale, ranging from strong disagreement to strong agreement. The items were translated to Finnish and modified so that they referred to the moment of looking at the confederate instead of the present moment. The instructions stated that the LC window would soon open and after that, the participants would be asked how they were feeling when they were looking at the other person. They were then shown all the nine questionnaire items to familiarize with them first. A text “The window will open as soon as Player #2 has read his or her instructions and pressed a button. Please wait.” was presented, after which the window turned transparent for four seconds and participants saw the confederate either looking at them or downward. They then completed the questionnaire regarding how they felt when the window was open. After this, participants read the same instructions again, saw the confederate now looking at the other direction and then completed the questionnaire regarding that situation. The order of the gaze directions was counterbalanced across participants.

After the SSAS, participants completed the Lying Frequency Questionnaire (Serota, Levine, & Boster, 2010). In the instructions, participants were asked to think back to where they were and what they were doing during the past 24 hours and to count how many times they had lied in that time. They were instructed to count all lies, big and small. They were then asked separately about lies to family members, friends, business contacts, acquaintances, and total strangers. For each type of recipient, they were asked separately about lies in face-to-face and mediated situations (by phone or in a written message). The instructions and the questionnaire items were translated to Finnish.

Finally, participants were asked to type out their answers to two questions about suspicions regarding the study design: “What do you think is the aim of this study?” and “Do you think that something was not told about the experiment?” The aim of these questions was to assess whether participants had guessed the research question or that the opponent was not a real participant, which would have altered their perception of the game and the experiment.

After the control questions, participants were informed that the game would not continue, and the experiment was finished. They were then told about the true nature of the study and the reasons for misleading them and given the participation reward along with the extra movie ticket.

4. Results

4.1. Manipulation and suspicion checks

A manipulation check question was used to assess whether participants had noticed variation in the gaze direction. To the question “How often do you estimate the opponent was looking at you when the window opened and you saw the opponent?” participants estimated, on average, the proportion of trials with direct gaze to be 60.98% ($SD = 23.42$, range = 10–95). Because all participants reported having noticed that the opponent had, at times, both looked at them and away from them, no participant was excluded based on this question.

Two suspicion check questions were used to assess whether participants guessed the research question or the confederate being a research assistant. To the question of the aim of the study, no one reported the correct research question and therefore no participant was excluded. To the question of thinking that something had not been told about the experiment, two female participants reported having suspected that the opponent was not a real participant, and they were excluded from the analysis, as mentioned in the method section.

4.2. Lying game

Lying in the game was measured as the number of dishonest responses, or stated more specifically, the number of blue circles reported as red. Participants lied, on average, 22.93 times ($SD = 13.51$, range = 1–50) on the 60 trials where a blue circle was shown. A paired samples t test indicated that participants lied less on trials where the blue circle was preceded by direct gaze ($M = 10.96$, $SD = 6.94$) than on those where it was preceded by averted gaze ($M = 11.98$, $SD = 6.98$), $t(45) = -2.06$, $p = .046$, $d = -0.30$. In accordance with the guidelines to reduce the risk of a type I error (Simmons, Nelson, & Simonsohn, 2011), the statistical analyses were repeated without any data exclusions and only with the exclusions due to technical problems, and in both reruns the effect remained significant ($p = .036$ and $p = .028$, respectively).

On average, participants made 0.67 mistakes ($SD = 1.56$, range = 0–6) of losing a point by reporting having seen blue when shown red, presumably due to lapse of attention or accidentally pressing the wrong key. The number of mistakes did not differ between the two gaze conditions, $t(45) = -0.90$, $p = .37$, $d = -0.13$.

Table 1
SSAS ratings by gaze direction.

	Direct		Averted					
Subscale	*M*	*SD*	*M*	*SD*	*t*(45)	*p*	95% CI	Cohen's *d*
Public	3.21	1.51	2.93	1.51	1.50	.14	[−0.10, 0.66]	0.22
Private	4.29	1.31	4.37	1.16	−0.77	.45	[−0.29, 0.13]	−0.11
Surroundings	4.01	1.52	4.27	1.41	−2.13	.039	[−0.51, −0.01]	−0.31

Note. CI = confidence interval.

4.3. Situational self-awareness

A paired samples *t* test was conducted to compare the self-awareness ratings on the SSAS in response to direct and averted gaze (see Table 1). There was no significant difference between the gaze conditions in public self-awareness, $t(45) = 1.50$, $p = .14$, $d = 0.22$, or in private self-awareness, $t(45) = -0.77$, $p = .45$, $d = -0.11$. However, a significant difference was found for awareness of immediate surroundings, $t(45) = -2.13$, $p = .039$, $d = -0.31$. Participants reported lower awareness of surroundings in the direct gaze condition ($M = 4.01$, $SD = 1.52$) than in the averted gaze condition ($M = 4.27$, $SD = 1.41$).

Public self-awareness was proposed to mediate the relation between eye contact and lying. However, because the predictor (gaze direction) did not have a significant effect on the hypothesized mediator (public self-awareness), mediation through public self-awareness was not possible (Baron & Kenny, 1986).

4.4. Lying in everyday life

In the Lying Frequency Questionnaire, participants reported having lied, on average, 2.49 times ($SD = 2.98$, range = 0–12) during the last 24 hours. There was a trend of a positive correlation between the reported number of lies during the last day and the total number of lies in the game, $r(45) = 0.27$, $p = .079$.

5. Discussion

The primary aim of the present study was to investigate the effect of another individual's direct gaze on dishonesty. This was achieved by using an interactive computer-assisted lying game that participants played against a confederate, whom they believed to be another participant. On each trial, participants were first briefly presented with a view of the confederate, after which they reported to the confederate the color of a circle appearing on the computer screen. Depending on the trial, the confederate was gazing either directly at the participants' eyes or downward. Participants were found to lie less on trials where the confederate gazed at the participants than on trials where he or she looked downward. There were 8.5 percent fewer lies on the direct gaze than the averted gaze trials corresponding to a small-to-medium effect size ($d = -0.30$).

This is the first study to demonstrate a watching-eyes effect on dishonesty that cannot be explained by increased adherence to rules. Previous studies on this effect have shown reductions in dishonest behaviors that have been clear violations to norms and rules, such as stealing (Nettle et al., 2012) or lying to experimenters (Oda et al., 2015). Lying, however, is not always against the norms and rules, as was the case in the present study. In the present study, a reduction in dishonesty was observed in a lying game where occasional dishonesty was allowed and expected, and thus arguably normative. Furthermore, in a broader sense, most previous findings on the behavioral effects of watching eyes, such as increased prosociality, generosity, and normativity, all suggest an increase in cooperative behavior. Increased cooperation has been argued to be the primary effect of the watching eyes, having its roots in human evolution (Ernest-Jones, Nettle, & Bateson, 2011). In this study, however, the reduction in lying in a competitive, head-to-head game can hardly be seen as increased cooperation. Therefore, instead of a mere increase in norm adherence or cooperation, the present findings demonstrate that watching eyes may reduce dishonesty in and of itself. In this sense, the results are novel and broaden the picture of the watching-eyes effects.

This study is also the first to show the effect of perceived direct gaze on dishonesty by using a live person as a stimulus and by measuring dishonesty as lying to that person in an interactive situation. Many researchers have argued for the use of truly interactive study designs in social cognition research instead of reducing social interaction to its parts and investigating these elements in isolation from each other (De Jaegher, Di Paolo, & Gallagher, 2010; Schilbach et al., 2013). Studies on social cognition typically use passive, spectatorial setups where the other person is replaced with an image presented on a computer screen. This makes the stimulus presentation more controllable and consistent, but it leads to a situation where the participants are merely observers without a possibility for interaction, thus removing important social aspects of the situation. Previous studies have shown a decrease in dishonest behavior by the perception of watching-eyes images instead of a live person's gaze (Bateson et al., 2006; Nettle et al., 2012; Oda et al., 2015), and by using a completely different kind of image, such as a picture of flowers (e.g., Bateson et al., 2006), as a control stimulus. The present study expands on the previous findings by showing that the watching-eyes effect on dishonesty can be generalized to seeing another individual's direct gaze in natural social interactions, and that it is the perception of direct gaze, not that of a face or eyes, that elicits the effect.

As a secondary goal, the psychological mechanism underlying the effect was examined. We hypothesized that public self-awareness, the awareness of an outer perspective on one's self, would be heightened in response to another's direct gaze and mediate the relation between eye contact and reduced lying. Self-awareness was measured with the SSAS questionnaire (Govern & Marsch, 2001). Unexpectedly, however, the confederate's gaze direction was not found to affect participants' ratings of self-awareness on the scale, and, consequently, the relation between eye contact and reduced lying could not be mediated by self-evaluated public self-awareness.

The unexpected result may be explained by the use of a self-report questionnaire for the measurement of self-awareness. Self-report measures are known to be problematic because people may not want to, or not be able to, evaluate and report their own subjective states honestly and accurately (Paulhus & Vazire, 2007). Self-report measurement of self-awareness has also lead to inconsistent findings in previous studies. Many studies have shown that another individual's direct gaze can increase self-rated public self-awareness (Hietanen et al., 2008; Myllyneva & Hietanen, 2015; Myllyneva et al., 2015; Pönkänen et al., 2011). However, in a recent study by Hietanen and Hietanen (2017), it was not affected by another's direct gaze, even though in that study, eye contact was found to increase first-person pronoun use implying heightened self-awareness. Interestingly though, in that study and in the present study, participants reported lower awareness of surroundings in response to eye contact. Awareness of surroundings is a measure of "non-self-focus" on the SSAS scale (Govern & Marsch, 2001, p. 368), and, based on the idea of attention as a bidirectional phenomenon focused either on the self or the environment (Duval & Wicklund, 1972), Hietanen and Hietanen (2017) proposed that the result reflects heightened self-focus. Given the above considerations, on the questions of the self-awareness effect of eye contact or the mediation of the honesty effect through self-awareness, the present results do not provide compelling evidence in one direction or another. However, the results of this study and previous studies do importantly indicate that self-report measures of self-awareness may be unreliable. Thus, further research on self-awareness and eye contact using alternative methods to self-reports is warranted.

As an increase in self-awareness was not found to mediate the effect, it is possible that some other psychological mechanism could account for it. One such explanation could be that eye contact reduces lying because of increased cognitive load, though for reasons related to the present study design, it does not seem very likely. Seeing a face with direct gaze may impair simultaneous cognitive performance (Conty, Gimmig, Belletier, George, & Huguet, 2010; Doherty-Sneddon & Phelps, 2005; Glenberg, Schroeder, & Robertson, 1998), and it has been shown that increased cognitive load reduces one's abilities to lie convincingly (Vrij et al., 2008). Maintaining eye contact, too, has been shown to impair this ability. In one study, requesting participants to maintain eye contact while telling true or false stories was found to make it easier for observers to tell when they were lying (Vrij, Mann, Leal, & Fisher, 2010). However, a careful inspection of this proposition and the present study design reveals that this is not a probable explanation for our findings. Lying is considered cognitively more demanding than telling the truth for several reasons. Lying requires making a decision to lie and constructing the lie (Walczyk, Roper, Seemann, & Humphrey, 2003). When lying, people also tend to monitor and adjust their behavior accordingly in order to appear honest (DePaulo & Kirkendol, 1989), while also observing the recipient's reaction to the lie (Schweitzer, Brodt, & Croson, 2002). In our experiment, however, very little construction of a lie was needed, as lying consisted only of pressing one key instead of another. Moreover, as the players could only see each other at the beginning of each trial before the color of the circle was presented, participants' decision to lie was not made during eye contact, but after it. For the same reason, monitoring one's behavior to appear honest was not needed and observing the recipient for signs of disbelief was not possible. Therefore, it seems unlikely that cognitive demands imposed by eye contact would explain the observed reduction in lying. Furthermore, because participants found out the color of the circle only after the window had been shut, they were not lying or even anticipating lying when the confederate saw them. Instead, while the window was open in the red and blue trials, they behaved identically. Therefore, the results cannot be explained by participants believing that the probability of being caught in a lie would be higher on the direct gaze trials due to the opponent seeing their intentions to lie, because of, for example, signs of restlessness or a guilty facial expression.

Another possible explanation is an increase in reputation management by the perception of another's direct gaze. As noted earlier, because lying was allowed in the game, the results could not be explained by an increased adherence to rules. Regardless of the rules, however, being caught lying is undesirable, and even shameful to most people, and therefore lying in the game did carry a certain reputational risk. Already early on in the research of watching-eyes effects, heightened concern of reputation was proposed to explain the findings (Bateson et al., 2006). This explanation is particularly powerful because, in addition to most results of increased prosocial and normative behavior, it can account for many of the null results of previous studies. Often in those studies, no actual reputational costs or gains could have been attained by the participants due to obvious anonymity of the situation (Cai et al., 2015; Fehr & Schneider, 2010; Lamba & Mace, 2010). Reputation management can also explain the results by Oda et al. (2015) of reduced prosocial lying because prosocial lying enabled by the study design could not have improved one's reputation, whereas being caught lying could have damaged it. Regarding the present study, it can be argued that the result of no increase in self-rated self-awareness is against this explanation. An increase in public self-awareness can indeed be expected with reputational concerns because it refers to conscious attention toward the way one is perceived by others (Fenigstein, Scheier, & Buss, 1975), which is largely synonymous with reputation. Reputation management (attempts to control others' impression of oneself), however, may also occur subconsciously without any attention to one's self or self-presentation (Schlenker, 1980). Therefore, an increase in reputation management by the perception of another's gaze remains a plausible, albeit speculative, explanation of the present results.

Additionally, we wanted to examine whether lying in the game was associated with lying in day-to-day life. For this purpose, a self-report questionnaire of lying in the past 24 hours was used. Participants were instructed to carefully think back over the last day and count the number of times they had lied to someone. A trend of positive correlation between lying in the game and reported lying in the past day was observed. As the same people who tend to lie more in their day-to-day life also lied more in the game, the result may indicate that there was some perceived similarity between everyday lying and lying in the game. The finding gives suggestive support for the external validity of the lying game and the use of this kind of games in the measurement of dishonest tendencies. However, as the correlation did not reach statistical significance, the result is only tentative and should be interpreted with caution.

One possible limitation of the present study was that participants were not caught lying even a single time. One can argue that, because of this, participants may have developed a feeling of invincibility in the game. However, this does not seem likely, because such a perception should have increased the rate of lying, and in the present study, the lying rate was actually lower than in the study that first introduced the game, where participants were occasionally also caught lying (Karton et al., 2014). Moreover, while not being caught could have aroused suspicions that the game was rigged, only two participants expressed such suspicions, and therefore the predominance of participants did not figure this out. However, as noted earlier, being caught lying is likely to induce negative, self-related emotions. It could have therefore increased the awareness of one's self and reputation and the perception of another's direct gaze as distressing or intimidating. These, in turn, could have increased the effect of another's gaze on one's behavior. Therefore, the observed effects could have been different, possibly stronger, if participants had been caught lying at least a few times during the game.

The presented results have practical implications for both everyday and professional situations. In Western cultures, people tend to look another person in the eyes when they are asking him or her something of particular importance, especially if there is a pronounced demand for an honest answer. This may be due to the common conception that avoiding eye contact is suspicious or due to heightened attentiveness to the other person (Kleinke, 1986). Be that as it may, the present results suggest that, in this kind of situations, the use of eye contact may indeed increase the probability for an honest answer. Similarly, the results have implications for professional contexts. Much of the research regarding lying and its detection has been conducted with a police interrogation context in mind (DePaulo et al., 2003). The present study provides further evidence for the use of eye contact in obtaining an honest answer, which may be useful information for professionals in this field. Furthermore, the practical implications extend to other professional situations that demand for, or benefit from, honesty in an interaction, such as clinical conversations, job interviews, and the like.

6. Conclusions

The perception of another individual's direct gaze was found to reduce subsequent lying to him or her. As far as the authors know, this is the first study to demonstrate that the perception of watching eyes reduces dishonesty in a setting where the effect cannot be explained by increased adherence to rules. The present study also showed, for the first time, the watching-eyes effect on dishonesty by having a live person with alternating gaze directions as a stimulus and by measuring dishonesty as lying to the other person in an interactive situation. No evidence of mediation of the effect through self-awareness was obtained. The findings have implications for both everyday and professional situations.

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