Eye gaze and arousal: Skin conductance responses to live and picture stimuli of another person's direct and averted gaze

University of Tampere
Department of Psychology
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Heidi Ruuhiala
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UNIVERSITY OF TAMPERE
Department of Psychology

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ABSTRACT

A direct gaze acts as a precursor to social interaction and has the power to elicit both behavioral approach and avoidance tendencies. It is also associated with changes in physiological arousal. Previous research has attained in part inconsistent results of the arousing effect of direct versus averted gaze. One factor contributing to these discrepancies has been the varying use of live and picture stimuli while investigating the effects of gaze direction on physiological arousal. The present study sought to address this by comparing physiological reactions to another person’s direct and averted gaze presented live or as pictures on a computer screen. Skin conductance responses from healthy adults were measured. The use of a liquid crystal (LC) shutter enabled the presentation of live stimuli in a highly controlled and accurate manner. In addition, subjective evaluations of the arousal and emotional valence experienced during different stimulus conditions were collected at the end of the experiment.

The results indicated greater skin conductance responses and, thus, higher arousal resulting from seeing a straight gaze as compared to seeing an averted gaze in a live condition. In addition, straight gaze in a live condition was associated with significantly lower self-reported pleasantness scores and significantly higher self-reported arousal scores as compared to those obtained for averted gaze. None of these effects were obtained using the picture stimuli presented on a computer screen. The results are consistent with previous findings of eye contact eliciting greater arousal than unreciprocated gaze with the use of live stimuli, as well as with studies that found no gaze effects with computerized stimuli. The possibility of the results deriving from a lack of a social context in the picture condition is discussed.

KEY WORDS: Eye contact, gaze direction, skin conductance responses, live stimulus

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1. INTRODUCTION

Gaze, as a part of non-verbal communication, has a significant role in human interactions. It conveys socially important information about other people's attitudes, goals, interests, emotional states, and focus of attention, potentially signalling an upcoming social interaction (Argyle, 1975; Baron-Cohen, 1995; for review, Emery, 2000; Kleinke, 1986). Gaze is an important visual communication signal, and together with gestures and facial expressions it plays a facilitatory role in human communication. Patterns of gaze and gaze aversion can serve a number of different functions, for example, for avoiding cognitive overload (Doherty-Sneddon**,** Bruce, Bonner, Longbotham**,** & Doyle, 2002) or regulating speaking turns (see e.g. Harper, Wiens, & Matarazzo, 1978). Direction of gaze can also signal a person's behavioral approach-avoidance tendencies and affect the perception of facial expressions of emotion (see Adams & Kleck, 2005). Adults use variables such as the presence, absence, frequency and duration of eye contact for inferring others' level of interest and the nature of a relationship (Kleinke, 1986).

Social contact often initially depends on determining the direction of another person's gaze. The perception of an averted gaze can elicit an automatic shift of attention (Driver et al., 1999; Friesen & Kingstone, 1998; Hietanen, 1999). Perceiving a direct gaze of another person, on the other hand, indicates that the direction of attention is focused on the viewer, thus, providing means for establishing a communicative context between the interactors. Mutual gaze has been described as one of the most fundamental and powerful modes of interpersonal encounter (Angus, Osborne, & Koziey, 1991).

Research on nonverbal communication and eye gaze has traditionally focused on the questions of encoding and decoding, with the former referring to the way feelings and relations are communicated in behavior, and the latter concerning the process of inferring others' feelings or attitudes from their actions (see e.g. Gonzaga, Keltner, Londahl, & Smith, 2001). In encoding experiments, participants' states are manipulated or measured and the nonverbal messages they display are investigated. The direction of gaze, length of glances, amount of eye-opening and pupil expansion have served as variables in these studies. In decoding experiments, participants are subjected to different gaze conditions and their reactions to these conditions are measured.

1.1. The role of gaze and eye-contact in human interaction

Faces are important visual objects that provide strong social cues, with the eyes bearing particular importance. The interpretation of another person's gaze is a key element of social cognition (see e.g. Baron-Cohen, 1995; Lobmaier, Fischer, & Schwaninger, 2006) and people are highly accurate at discriminating whether another person is gazing directly at them or whether the gaze is averted (Anstis, Mayhew, & Morley, 1969; Cline, 1967; Masame, 1990; Martin & Jones, 1982), especially when the other person's face is seen from straight ahead. However, the presence of an object can influence the perceived gaze direction, supporting the view that gaze processing is biased toward the assumption that a person is looking at an object rather than at an empty space (Lobmaier et al., 2006). People's accuracy in estimating the amount of time that another person is gazing at them is often low (see Kleinke, 1986). For example, in a study by Argyle and Williams (1969) participants were unable to distinguish between the gazing behaviors of a confederate who intentionally gazed at them 80 % or 20 % of the time. Accuracy in assessing the amount of another person's gaze can be affected by one's attention and mindfulness toward the interaction as well as by personal motives and expectations (Kleinke, 1986). Zajonc (1980) found that people can be influenced by another person's gaze without being aware of it. It is suggested that awareness of this influence should be greatest when the effects of the gaze are salient and plausible (Taylor & Fiske, 1978). In another study, approximately half of the subjects were aware of the gazing behaviors of a confederate who gazed at them constantly, intermittently, or not at all during a conversation, and consequently were more influenced in their ratings of the characteristics of the confederate (Cook & Smith, 1975).

Sensitivity to eye gaze direction begins to develop early in humans (Caron, Caron, Roberts, & Brooks, 1997; Farroni, Csibra, Simion, & Johnson, 2002; Hains & Muir, 1996; Hood, Willen, & Driver, 1998; Vecera & Johnson, 1995). Infants both stare longer at the eyes than other facial features (Maurer, 1985) and prefer faces with straight gaze over faces with averted gaze (Caron et al., 1997; Hains & Muir, 1996). Gaze and mutual gaze have an important role in the development of sociability and attachment (Argyle, 1975), and adult gaze is also crucial for stimulating vocalization in young children (van Egeren & Barratt, 2004; Bloom, 1975). During the prelinguistic babbling period of normally developing children, conversational patterns can be found in the infant-adult gaze behavior (Jaffe, Stern, & Perry, 1973). Gaze behavior also provides a way for infants to approach and withdraw from others in an effort to control their internal states and regulate their emotional experiences (Doherty-Sneddon et al., 2002; Stern, 2002).

The development of gaze processing in healthy infants follows a specific time course. Infants' growing ability to follow another person's gaze is well documented (e.g. Corkum & Moore, 1998; Scaife & Bruner, 1975), although the age at which it first appears is controversial, ranging typically from 6 to 18 months (see Emery, 2000). Gaze following is a crucial developmental bridge, because it connects observable bodily acts with referential meaning about objects in the external world (Brooks & Meltzoff, 2002). It is also relevant for understanding the meaning of an emotional facial expression because a person's emotional behavior is often connected to what he or she sees in the external world (Brooks & Meltzoff, 2002). By 18 months, infants establish new word–object associations, based on an understanding that a novel verbal label is connected to the target of the speaker's gaze (Tomasello, 1995). Children's use of gaze as a "mind-reading" tool continues to develop after infancy, and 4-year-olds are able to use gaze direction alone for inferring the object of a gazer's reference, desire and intentions (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995). The observation that this ability is absent among children with autism has led to the growing understanding of the importance of sensitivity to the mentalistic significance of the eyes in the development of "mind-mindedness" or a theory of mind (Baron-Cohen et al., 1995). Over the course of development the role of eye contact remains central in social functioning.

Patterson (1982), in his sequential analysis of nonverbal exchange (NVE), distinguishes three stages of nonverbal interaction: antecedents, preinteraction mediators, and an interaction phase. Antecedent factors, including personal, experiential, and relational-situational determinants, participate in the moderation of gaze and eye contact by initiating preinteraction mediators. Patterson describes these mediators structuring the perceived functions of an interaction and the levels of nonverbal involvement initiated by each interactant. Different functions in an interaction produce differing arousal, cognitive, and behavioral patterns in interactants. Kleinke (1986) has applied Patterson's functional classification of nonverbal behaviors in describing how eye gaze functions in providing information, regulating interaction, expressing intimacy, exercising social control and facilitating service and task goals, with the understanding that gaze typically serves more than one function on any particular occasion.

Gaze behavior serves as an important cue in the process of social evaluation. Gaze has been reported influencing the evaluations of liking and attraction, object preference (Einav & Hood, 2006), attentiveness (Kleinke, Staneski, & Berger, 1975), competence, social skills (Bellack, Hersen, & Lamparski, 1979), mental health, credibility, and dominance (Argyle, 1975; Kleinke, 1986). Studies support the hypothesis of association between gaze and liking being a learned rather than an innate ability (e.g. Abramovitch & Daly, 1978). Although positive attraction increases gazing behavior, moderate amounts of gaze are generally preferred over constant or no gaze (Argyle, Lefebvre, & Cook, 1974). Kleck and Nuessle (1968) noted that a high level of eye gaze can be associated not only with more favorable but also with more tense evaluations of the person who is looking.

Gaze avoidance is positively correlated with evaluations of anxiousness and low self-esteem (Droney & Brooks, 1993), and negatively correlated with evaluations of sincerity, relaxation and dominance (see Larsen & Shackelford, 1996). People have a tendency to associate gaze aversion with deception (e.g. Rotenberg, & Sullivan, 2003). Deception research has, however, conclusively demonstrated that gaze behavior is not related to deception (DePaulo et al., 2003; Mann, Vrij, & Bull, 2004; Sporer & Schwandt, 2007). A recent study investigated attention orienting triggered by faces that always looked to the target (predictive-valid), never looked to the target (predictive-invalid) or looked toward and away from the target in equal proportions (nonpredictive). The predictive-valid faces were reported appearing more trustworthy than the predictive-invalid faces, reflecting the interactions among attention, gaze perception, and personality judgments (Bayliss & Tipper, 2006).

Gaze can also be used to communicate threat. In non-human primates, autonomic physiological changes have been reported to accompany the detection of eye contact, suggesting that eye gaze is an emotive stimulus (see Emery, 2000), and one of the most frequently reported components of threat displays in primates is, indeed, a steady, direct gaze at the object of aggression (Ellsworth, Carlsmith & Henson, 1972). Some studies suggest a similar effect on humans (see Argyle, 1975; Ellsworth et al., 1972). However, the results may simply reflect reactions to social rule-breaking and invasion of privacy (see Ellsworth et al., 1972). Furthermore, eye contact is associated not only with aggression but with a variety of sentiments, such as affiliation and interest, and it is suggested that in the absence of negative or hostile cues, eye contact is often seen as a sign of friendliness (Ellsworth et al., 1972). In the right context, a stare has been found to promote a friendly, helpful approach, even between strangers (Ellsworth & Langer, 1976).

A study by Kimble, Forte and Yoshikawa (1981) supports the notion that gaze communicates the intensity but not the valence of feelings. They detected that participants gazed more when they were asked to communicate strong rather than weak feelings and that this was true for both positive and negative feelings. More recent studies, however, have found evidence indicating that emotions are conveyed in more frequent channels than usually studied, including posture, gaze patterns, voice, and touch (see Keltner & Shiota, 2003). The spontaneous affective reaction of expressing intimacy through gaze behavior can be witnessed in situations where gazing is increased due to positive attraction between interactants. This phenomenon is demonstrated e.g. in a study where participants were asked to approach an imaginary person they liked (Mehrabian, 1968). In a study by Gonzaga et al. (2001), mutual gaze, among other variables, was associated with the expression of momentary experience of love. However, high levels of gaze do not always indicate intimacy and liking, but are most typically associated with these positive affects in unstructured and nonevaluative interactions (Patterson, 1982).

Gaze cues can facilitate verbal communication by taking part in conversational sequencing with linguistic, paralinguistic, and other kinesic variables (Rosenfeld, 1978). Gaze functions as a turn-taking cue by smoothing the exchange of speaking turns e.g. with a prolonged gaze at the end of an utterance (see Kleinke, 1986). Examples of synchronization can be found in the parallel rates of gaze shifts in two-person conversations and in a high correlation between interactants' length of gaze (Harper et al., 1978). Gaze also acts to coordinate joint visual attention (Richardson, Dale, & Kirkham, 2007), and the visibility of one's conversational partner can improve information transfer and the management of turn taking during problem solving tasks (Boyle, Anderson, & Newlands, 1994). In general, gaze serves as a means for communicating positive intents and, thus, fosters cooperation, although some exceptions do exist (Kleinke, 1986). For example, in situations in which people use gaze to threaten one another, preventing visual accessibility can enhance cooperation (Carnevale, Pruitt, & Seilheimer, 1981).

Several studies have investigated the social control functions of gaze in persuasion and deception, ingratiation, threat and dominance, escape and avoidance, and compliance (see Kleinke, 1986). Prolonged and unexplained gaze, for example, has been reported to elicit escape and avoidance responses. When the meaning of a stare is ambiguous, people are disposed to move away from a staring stranger. However, if the staring stranger has favorable attributes, a cognitive assessment can result in more favorable responses (Kleinke, 1986). In situations in which gaze is interpreted positively, eye contact can in fact enhance helping behavior (e.g. Guequen & Jacob, 2002). Patterson (1982) noted that gaze in social control function is maintained until it achieves its intended purpose. Gaze may, as a result, frequently exceed the limits of comfort or appropriateness in interactions, which in turn can lead to an unstable exchange (Kleinke, 1986).

Researchers have investigated relations between gaze and personal factors such as age, gender, personality, culture, and different clinical diagnoses. It has been proposed that deficits in eye-gaze perception are possibly symptomatic of, or may even contribute to, autism (e.g. Klin et al., 1999), with impairments found in several different levels of gaze processing, such as gaze following, joint attention, eye contact, and understanding gaze within a mentalistic framework (see Emery, 2000; Farroni et al., 2002; Larsen & Shackelford, 1996). Deficits in gaze processing have also been associated with schizophrenia. There is evidence indicating that schizophrenic patients, especially the paranoid schizophrenics, are more likely to inaccurately report that a face is looking directly at them than control subjects. This was true for tasks in which participants were required to use themselves as a reference (mutual gaze) (see Emery, 2000). However, in a forced choice task of gaze discrimination based on spatial orientation (direction of gaze), the schizophrenic patients performed as well as the control subjects, suggesting that in schizophrenia an impairment is present in gaze interpretation rather than in gaze direction detection (Franck et al., 1998).

Studies have shown that gazing is a relatively consistent and stable behavior (Argyle, 1975; Daniell & Lewis, 1972), and different gazing patterns have been associated with different personal characteristics (see e.g. Larsen & Shackelford, 1996). In general, it can be noted that gaze behavior can vary in different age groups, but that several factors influence gazing at all ages, and only the prepotency of these factors varies with age (Kleinke, 1986). Gaze aversion, as a cognitive load control mechanism, has been found to develop throughout the early primary school years (Doherty-Sneddon et al., 2002). Concerning the gender differences in gaze behavior, it has been found that females generally gaze more than males in social dyadic interactions (Argyle, 1975; Duncan & Fiske, 1977; Leeb & Rejskind, 2004). This is true for both children and adults, and has been explained in terms of socialization, sex roles, status differences, or genetic predispositions (Hall & Friedman, 1999; Henley, 1995; Leeb & Rejskind, 2004). Women also seem to have more positive reactions than men when receiving gaze from others (Kleinke, 1986). Harper et al. (1978) discussed Aiello's (1972) observation that men prefer far seating distances when gazing at someone, while women prefer intermediate distances. This may reflect people's attempt to seek levels of intimacy that result in most comfort by adjusting their interaction distances (Kleinke, 1986).

The rules that are used for defining appropriate and inappropriate gazing behaviors vary between different cultures. For example, gaze avoidance can be interpreted as a sign of insincerity or as a gesture of respect, depending on the cultural context (Kleinke, 1986). Cross-cultural observations suggest that gazing behaviors are to a great extent learned behaviors, with each culture possessing its subtle yet implicit norms and expectations of gazing behavior. Gaze displays during thinking are traditionally thought to be driven by endogenous brain activities associated with cognitive strategies to avoid distraction. However, a recent study demonstrated that gaze displays while thinking are at least in part culturally determined (McCarthy, Lee, Itakura, & Muir, 2006).

In addition to personal factors, also experiential factors, such as learning history and mood, as well as relational-situational factors affect gaze behavior. The nature of the interaction affects the level of gaze that is appropriate for the occasion (Kleinke, 1986). People have a tendency to increase their gaze when expecting a negative interaction in order to attain a friendly outcome (Ickes, Patterson, Rajecki, & Tanford, 1982) and to encourage an appropriate level of intimacy to support stable exchange (Coutts, Schneider, & Montgomery, 1980).

1.2. The visual processing of eye gaze

Research from various fields indicates that humans have a specialized neural system for detecting the presence of eyes and the direction of other people's gaze (Baron-Cohen, 1995; for review Emery, 2000). Whether this gaze module is already operating in neonates has so far remained unconfirmed. Supporting evidence for an innate system for detecting eye-like stimuli in the environment and orienting attention towards them was obtained in a study by Batki, Baron-Cohen, Wheelwright, Connellan, and Ahluwalia (2000). They used a preferential looking paradigm and observed that newborns preferred a photo of a female face with eyes open over the same face with eyes closed. In another study, newborn infants were reported to prefer a face that engaged them in mutual gaze, and healthy babies, from an early age, also showed enhanced neural processing of direct gaze (Farroni et al., 2002).

Viewing changes in eye gaze has been reported to generate activity in the human MT/V5 area in the occipitotemporal cortex (see Watanabe, Kakigi, Miki, & Puce, 2006). Neuroimaging studies have provided evidence for involvement of the superior temporal sulcus (STS) (Hooker et al., 2003; Wicker, Michel, Henaff, & Decety, 1998), the intraparietal sulcus (IPS) (Hoffman & Haxby, 2000), and amygdala (Kawashima et al., 1999) in gaze perception. Gaze is usually perceived in the context of a face, and faces are known to activate both the fusiform gyrus and the STS (Kanwisher, McDermott, & Chun, 1997). However, recent neuroimaging studies have suggested that the fusiform gyrus responds more to whole faces whereas STS activity is more associated with facial features, particularly the eyes (Hooker et al., 2003). These differences were demonstrated in a study where the same visual stimuli were used for making face identity judgments and gaze direction judgments (Hoffman & Haxby, 2000). Wicker et al. (1998) identified a distributed network involved in the perception of eyes regardless of the direction of the gaze. They did not, however, find conclusive evidence for specific areas devoted to mutual gaze processing. In other studies, STS region was more active in response to averted gazes than straight gazes (Hoffman & Haxby, 2000) and the right amygdala had a stronger role than the left one in situations of direct gaze (George, Driver, & Dolan, 2001). Jenkins, Beaver and Calder (2006) propose that humans have distinct populations of neurons that are selectively responsive to particular directions of seen gaze. They base their proposition on an observation of selective adaptation to averted gaze, which did not reflect adaptation to low-level visual properties or a general spatial bias. Watanabe et al. (2006) on the other hand argue, based on their findings on a MEG study, that processing of eye gaze change is not sensitive to eye direction per se but rather to the eye gaze relative to the viewer.

Our tendency to direct attention to where another person is looking is well documented (e.g. Hietanen, 1999; Kingstone, Friesen, & Gazzaniga, 2000; Vecera & Johnson, 1995), and several studies have found evidence for the reflexive nature of this tendency (e.g. Driver et al., 1999; Friesen, Ristic, & Kingstone, 2004), that allows the establishment of joint attention, although recently a contraindicating argument has emerged, suggesting an involvement of controlled endogenous processes in the shifts of visuospatial attention (Vecera & Rizzo, 2006). Hietanen, Nummenmaa, Nyman, Parkkola, and Hämäläinen (2006), however, found strong evidence for partially separate cortical networks and mechanisms for attention orienting by gaze cues and attention orienting by arrow cues, and pointed out, that while arrow-cued shifts of attention may be more dependent on the neural mechanisms involved in voluntary shifts of attention, another person’s gaze may trigger reflexive shifts of visual attention. Studies on split-brain patients (Kingstone et al., 2000) and healthy adults (Okada, Sato, & Toichi, 2006) have suggested that the reflexive attentional shift in response to gaze direction is processed dominantly in the right hemisphere, also responsible for face perception. George et al. (2001) found stronger responses in fusiform regions for direct than averted gaze. Direct gaze, indicating the likelihood of imminent social interaction, was suggested to elicit a more attentive analysis of the person’s face. In addition, direct gaze has been reported to enhance the perception of approach-oriented emotions (anger and joy), while averted eye gaze enhanced the perception of avoidance-oriented emotions (fear and sadness) (Adams & Kleck, 2005).

1.3. Gaze direction and arousal

Electrodermal activity (EDA) is considered to be a measure of the state of the organism's interaction with its environment (Stern, Ray, & Quigley, 2001), and has been closely linked with the psychological concepts of emotion, arousal, and attention (Dawson, Schell, & Filion, 1990; Ellsworth & Langer, 1976). It has been suggested that skin conductance responses (SCR), as a measure of EDA, reflect both changes in emotional responding as well as cognitive activity (Siddle, 1991). SCR measuring changes in skin's phasic electrodermal activity is sensitive to novel, unexpected, significant, or aversive stimuli (Dawson et al., 1990), as well as to stimuli which are threatening, emotional, or attention-getting (see Fowles, 1986). The SCR is accordingly believed to be a reliable accompaniment of orienting reflexes (Dawson et al., 1990). In general, stimuli whose efficacy depends more on their psychological significance (e.g. familiar faces; see Tranel, Fowles, & Damasio, 1985) rather than to their physical intensity (e.g. high contrasts) are more likely to elicit SCRs (Fowles, 1986). For these reasons, SCR has widely been used as a measurement of arousal in psychophysiological experiments.

Valence and arousal are described as motivational parameters that define both a general disposition to approach or avoid stimulation and the vigor of this directional tendency (Lang, Bradley, & Cuthbert, 1992). The mobilization of electrodermal and other visceral changes are also assumed to be modulated by the same motivational systems (Lang, Greenwald, Bradley, & Hamm, 1993). SCR has been shown to be an effective indicator of emotional response but it does not reveal the valence of the response. In accordance with this, conductance increases have been found to vary directly with reports of arousal, independent of whether the experience is reported as pleasant or unpleasant (Cook, Hawk, Davis, & Stevenson, 1991).

The relationship between the central nervous system and EDA is still in part unclear. Stern and colleagues describe Boucsein's (1992) two-component model in which two complementary systems control the EDA activity, with the first component controlling EDA when the stimulus is of an emotional or affective nature and the second component controlling EDA during orienting, cognition and locomotion (Stern et al., 2001). The peripheral mechanisms of EDA are based on the activity of sympathetically innervated eccrine sweat glands that respond primarily to psychic stimulation via chemical transmitter acetylcholine (Stern et al., 2001). The eccrine sweat glands that are located on the palmar surfaces of hands are used for the recording of SC because of their high density on these areas. The degree of sympathetic activation determines the amount of hydration as well as the number of active sweat glands, thus affecting the skin's resistance (Dawson et al., 1990). Other variables such as the reabsorption of sweat may also affect EDA (Stern et al., 2001). Advantages associated with the use of SCR result from its rather discriminable occurrence. Moreover, electrodermal activity is usually determined primarily by motivational or attentional arousal, or by some other nonsomatic process, whereas heart rate, for example, is regulated mainly by movement control mechanisms (Dawson et al., 1990).

Studies investigating the link between gaze and arousal have reported eye contact producing greater SCRs than averted gaze (McBride, King, & James, 1965; Nichols & Champness, 1971). Strom and Buck (1979) reported an increase in the SCRs to staring versus non-gazing confederates. Other researchers have reported no effects of gaze direction (Leavitt & Donovan, 1979) or only marginal differences between eye contact and averted head condition (Donovan & Leavitt, 1980) on electrodermal activity. When comparing the SCRs to straight and averted gaze in children with autism and normally developing controls, only the clinical group showed significantly greater responses in the eye contact condition than in the averted gaze condition (Kylliäinen & Hietanen, 2006). Differential effects of eye contact and unreciprocated gaze on arousal have also been identified with the use of other psychophysiological measurements. Gale, Spratt, Chapman, and Smallbone (1975) studied changes in physical arousal related to gaze, and reported higher electroencephalographic (EEG) arousal to eye contact than to averted gaze. Martin and Gardner (1979), however, found no effects of gaze direction while using EEG as an index of arousal. Eye contact has also been associated with increases in heart rate (Kleinke & Pohlen, 1971).

Sharing an eye contact with an opposite-sex person as opposed to a same-sex person has been reported to result in higher arousal (McBride et al., 1965). Other studies, on the other hand, have not obtained significant sex differences (Nichols & Champness, 1971), or have found a general tendency for male faces to elicit greater SCRs in both male and female subjects (Donovan & Leavitt, 1980). However, when measuring arousal in heart rate (HR) responses, Donovan and Leavitt (1980) found an interaction effect of stimulus gender by participant gender, with greatest responses resulting from a male participant viewing another male. Altogether, the results concerning the gender effects on arousal have been fairly inconsistent.

1.4. The mode of presentation of social stimuli: picture versus live

Lang et al. (1993) proposed that "pictorial information can match the stimulus properties of real object, activating cognitive representations associated with strong emotional responses". They continued to argue that this affective processing, in turn, can trigger visceral motility similar to that engaged by the veritable stimuli, which can closely parallel evaluations of affective meaning. Pictures of faces have, indeed, been successfully used in numerous studies investigating e.g. face perception and recognition (see e.g. Goffaux, & Rossion, 2007). However, when studying changes in arousal to direct and averted gaze, the effects have not been consistently attained with the use of static photographs as stimuli. For instance, Nichols and Champness (1971) used live confederates in their study and found that eye contact produced greater GSRs than unreciprocated gaze. Leavitt and Donovan (1979), contrarily, reported no differences on SCR on mothers who viewed pictures of gazing and non-gazing infants on a television monitor. With normal children and adults, seeing live towards gazing faces, on the other hand, has been associated with stronger SCRs than seeing a paper cup (Hirstein, Iversen, & Ramachandran, 2001), suggesting, that for normal children and adults, live faces hold special stimulus value. Wicker et al. (1998) have suggested that pictorial stimuli may produce different experience from live faces while studying the effects of the intense experience of eye contact, found in natural face-to-face encounter. In addition, it has been suggested that the changes in arousal are not elicited purely by another person's gaze but that they also depend on the interpretation of the social context (Patterson, Jordan, Hogan, & Frerker, 1981). Eye contact with a live opposite-sex person has accordingly been reported to produce greater arousal than eye contact with a life-size photograph (Bailey, Chorosevic, White, & White, 1981).

Donovan and Leavitt (1980) studied physiological reactions to direct and averted gaze in adults, and argued that showing the gaze stimuli via a television monitor is justifiable because a more accurate regulation of parameters, such as onset, intensity, spontaneity, duration of the stimuli, and consistency of facial expressions, can be obtained with the use of computerized stimuli, and that comparable precision with a live confederate would be difficult to attain. They however also suggest that the use of filmed subjects in their study might be the underlying reason for the only marginally significant changes in SC during eye contact versus unreciprocated gaze. One option would be to create dynamic displays, or "movie clips", of faces that can shift eye gaze and if necessary change expression (see Putman, Hermans, & van Honk, 2006; Watanabe et al., 2006). The use of dynamic displays, however, does not remove the problems stemming from the unique properties of mutual gaze in real life, for example, the reciprocal experience of "meeting of minds" (see Angus et al., 1991), that can not be imitated or reproduced to full satisfaction even by moving computerized stimuli. Thus, an experimental setting which enables both the use of live faces as stimuli as well as the controlled and temporally accurate presentation of these stimuli would be called for. One method to meet these demands would be to present live gaze stimuli via a large-sized shutter positioned between the participant and the model person. A shutter with fast opening and closing controlled by a computer can overcome both problems concerning the authenticity of the stimuli and a lack of social context as well as the need for precision of the presentation of the stimuli. Thus, it can be proposed that although the use of photographs of faces or schematic faces as stimuli can be methodologically justified in several experimental settings, when studying effects of gaze direction on arousal, the use of live stimuli with appropriate stimulus presentation equipment should be opted.

1.5. The present study

The present study sought to investigate the physiological reactions of healthy adults to seeing of human faces with varying gaze directions presented as pictures or live. The stimuli consisted of static pictures presented on a computer screen and live stimulus persons viewed through a liquid crystal (LC) shutter. The gaze was directed either directly towards (eye contact condition) or 30° to the left or right from the observing participant (averted gaze condition). A radio (live and picture) was presented as control stimulus. The radio was also presented in straight and averted orientation imitating the face conditions. During the presentation of pictures and live stimuli, SCR was measured. Subjective evaluations in terms of experienced valence and arousal during different conditions were collected at the end of the experiment.

The first hypothesis for the experiment was that direct gaze would produce greater levels of arousal than averted gaze. Previous research has provided evidence for greater skin conductance responses to straight versus averted gaze (McBride et al., 1965; Nichols & Champness, 1971) although some contraindicating evidence exists (see Leavitt & Donovan, 1979). Secondly, it was assumed that faces would produce greater SCRs than the control stimuli (see Hirstein et al., 2001). With the use of control stimuli we aimed to rule out the possibilities of mere directional or conditional effects, i.e. the stronger SCRs deriving from straight direction instead of straight gaze per se, or live objects in general causing the effect rather than live faces specifically. Third, the effect of gaze on arousal was assumed to be stronger in live condition. Finally, because previous studies have shown that subjective ratings of arousal can correlate with the measured SCRs (Lang et al., 1993), we wanted to examine whether this physiological arousal effect was related to self-ratings of subjective experiences of arousal and emotional valence during each condition. The effect of sex between the participant and the stimulus person (same or opposite) was also investigated but no hypotheses regarding the expected results were set.

2. METHODS

2.1. Participants

Fourteen female and twelve male participants took part in this experiment. Twenty-four of the 26 subjects were undergraduate students at the University of Tampere and received credit for their participation. Of the original 26 subjects, 1 subject was excluded for measurement problems associated with the recording of electrodermal responses; 1 subject for equipment malfunction; 3 subjects for procedural errors; and 2 subjects for reported high anxiousness or laughter during the experiment. This left a total of 19 subjects: 10 females (mean age 22.6 yrs, sd. 2.84) and 9 males (mean age 28.3 yrs, sd. 5.22).

2.2. Stimuli and apparatus

Six colour photographs of the two female experimenters with a grey background served as the facial stimuli in the picture-face condition. The eyes on the pictures were gazing either straight to the camera or 30˚ to the left or right while the head position remained direct, facing the camera. The different eye positions on each picture were created by ‘cutting and pasting’ the irises and pupils of the eyes from other pictures of the same model into the stimulus face. The same faces and the same orientations of the eyes and the head as in photographs were also used in the live condition. All other nonverbal cues, for example facial expressions, were kept as neutral as possible and blinking was avoided. The inter-ocular distance of the stimulus face was adjusted to 12˚ in both live and computer presentation conditions. In addition, a radio and pictures of a radio in direct and 30˚ averted orientations were presented as control stimuli. Hence a total of 9 different pictures and 9 different live stimuli were used in the experiment.

Figure 1. Examples of the stimuli used in the computer screen conditions i) face-condition (upper pictures) and ii) control-condition (lower pictures).

Stimulus presentation was controlled by Neuroscan Stim software in both live and picture presentation conditions. The SCR data were collected using Power Lab Chart v3.6 programme and sampled with a 100 Hz time resolution. In the computer presentation conditions the stimuli were presented on a 17-inch computer monitor (75 Hz, Nokia 930C). In the live conditions a panel containing a window with a liquid crystal (LC) shutter (40x30 cm) was placed between the participant and the experimenter/control stimulus, depending on the condition. Between the stimulus presentations the optical-shutter was kept opaque. The LC shutter can be made transparent within a millisecond range by applying a voltage, thus enabling the presentation of live stimuli with a strict control of timing. The position and retinal size of the stimulus faces were maintained equal across the live and computer presentation conditions.

2.3. Procedure

At the beginning of the experiment, the participants were asked for some relevant background information (i.e. age and handedness) and consent for the use of the collected data. The experimental procedure was explained and the participants were familiarized with the measurement and stimulus presentation equipment. Electrodes for recordings of SCR, EEG and ECG were applied according to standard procedures. From the collected physiological measurements, only SCR data will be presented in this paper. The electrodes used for SCR recordings were coated with electrode gel and attached to the medial phalanx of the index and middle fingers of the participant's non-dominant hand which had been cleaned with an antiseptic liquid. The participants were instructed to sit in front of a computer screen or an optic window in a dimly-lit quiet room, and to concentrate on the stimuli presented to them while remaining relatively still during the trials. No task was required of the subjects, except to watch the stimuli as naturally as possible.

Participants were randomly assigned to one of four counterbalanced block orders (live-face stimuli, live-radio stimuli, computer-face stimuli or computer-radio stimuli first). Both live and both computer tasks were presented consecutively. In order to avoid habituation effects, the faces and control stimuli were different in live and computer conditions. In addition, for the purpose of eliminating the effects of a specific face, the presentation of one of the two possible faces in a given condition alternated with every other participant. During the computer conditions, static photographs of faces and control stimuli were presented on the computer screen for 5 seconds, while the participants sat at approximately 70 cm from the screen. In live conditions they were seated 90 cm in front of a panel containing the optical-shutter and at approximately 120 cm from the experimenter, who sat on the other side of the panel. Participant's and experimenter's seating positions were adjusted in order to obtain eye contact. The inter-stimulus interval varied randomly from 30 to 45 seconds, measured from the stimulus offset. To ensure that the participant was looking towards the face or control object at the stimulus onset, a tone signal was presented 5 seconds prior to the stimulus onset. The stimuli were presented in four blocks. The blocks consisted of face and control stimuli, presented in live and computer conditions. On each block, the participants received a total of 12 trials per condition, consisting of 6 stimuli with straight and 6 stimuli with averted orientations (3 on each side) presented in random order.

At the end of the experiment the participants were asked to fill out a pencil-and-paper version of SAM (Self-Assessment Manikin; see e.g. Hempel et al., 2005; Lang et al., 1993). The SAM ratings were used to evaluate the participants' subjective experiences of arousal and pleasantness during each stimulus presentation. These ratings of arousal and emotional valence were collected after the actual experiment by asking the participants to recall their experiences during the presentation of each stimulus on each block. The method of gathering subjective ratings at the end of the experiment, instead of gathering it separately after each block, was employed in order to avoid possible expectancy effects which could impact participant's arousal or concentration during subsequent conditions. The SAM consisted of two scales; arousal and pleasantness, each containing a 9-point scale. The participants were instructed to rate their experiences on both SAM dimensions.

2.4. Data analysis

The data were visually inspected for detection and removal of artifacts. A total of 4.7 % of the entire SCR data was excluded due to unreliable responses, of which 48 % were responses to computer presentation stimuli and 52 % to live stimuli. Face and control stimuli were equally represented in the excluded trials. All mean values used in the analyses were calculated from a minimum of 4 trials. The magnitude of the skin conductance response to each stimulus was determined by computing the difference between SC level in μS at stimulus onset and the maximum SC reached during a 4−second interval starting 1 s after stimulus onset. In addition, for each trial the value of the SCR was calculated every second, starting 1 s after stimulus onset until 5 s after stimulus onset. These values were also obtained using the stimulus onset value as a baseline. Thus, 5 data points and a maximum value were calculated for each trial, resulting in both response magnitude data and a time series of the skin conductance measures.

Statistical package for the Social Sciences (SPSS) version 13.0 was used to analyse the data. The normality of the distribution was tested and it showed that the data were not normally distributed (Kolmogorov-Smirnov, $D(152) = .226$, $p = .001$). A logarithmic transformation, which is often used with positively skewed distributions, was conducted. Due to zero responses, that were included in the SCR magnitude data, a log(SCR + 1.0) was calculated (see e.g. Dawson et al., 1990). All the statistical analyses were performed with the transformed values.

3. RESULTS

The maximum response data were analysed with a 2 x 2 x 2 x 2 ANOVA (repeated measures). Gender served as a between-subjects factor, while direction (gaze/radio straight or averted), condition (live or computer monitor) and stimulus (face or control) were within-subjects factors. This analysis indicated no significant effect or interactions regarding gender and, therefore, the data were collapsed on this dimension in all further analyses. Table 1 presents means of the maximum SC responses for each condition, while Figure 2 presents changes in skin conductance as a function of time in different conditions.

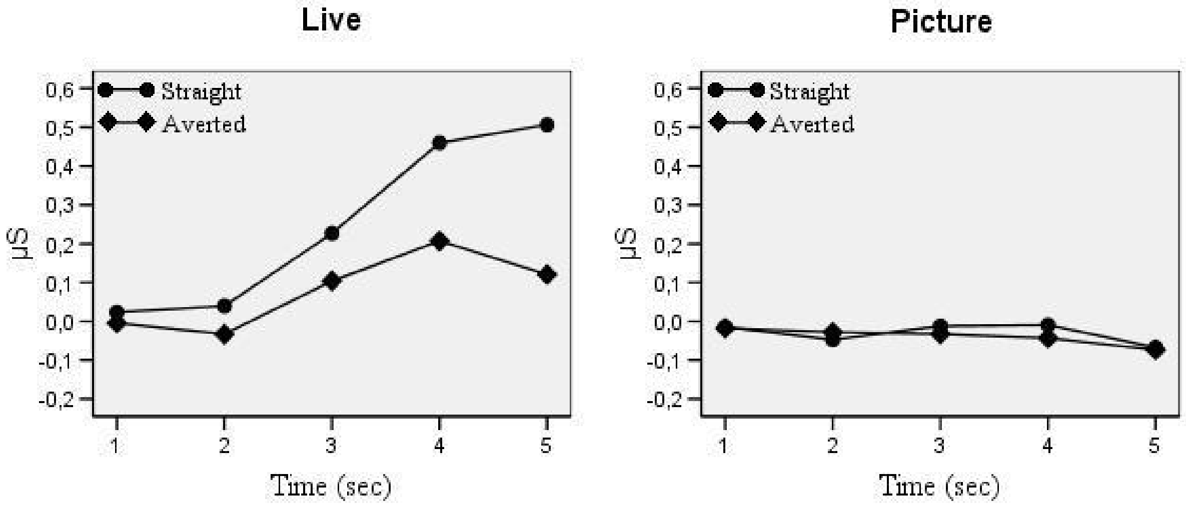
Table 1. Means of the maximum skin conductance responses (µS) and standard errors of mean as a function of stimulus presentation condition, stimulus, and direction.

	Live				Picture		
	Direct		Averted		Direct		Averted
Face	0.63 (0.13)		0.36 (0.10)		0.12 (0.05)		0.07 (0.02)
Control	0.12 (0.05)		0.13 (0.06)		0.06 (0.03)		0.01 (0.03)

A 2 x 2 x 2 (stimulus x condition x direction) analysis of variance for the transformed SCR data revealed a significant main effect for stimulus, *F*(1, 18) = 24.7, *p* = .001. Inspection of the means indicated that this effect was due to faces (*M* = 0.293, *SE* = 0.062) eliciting larger responses than control stimuli (*M* = 0.079, *SE* = 0.029). A main effect also emerged for condition, *F*(1, 18) = 16.5, *p* = .001, such that live condition (*M* = 0.309, *SE* = 0.075) produced greater responses than picture condition (*M* = 0.063, *SE* = 0.016). Moreover, the main effect of direction also reached significance, *F*(1, 18) = 11.2, *p* = .004, arising from greater SCR's to straight (*M* = 0.233, *SE* = 0.049) versus averted (*M* = 0.139, *SE* = 0.039) condition. These main effects were, however, qualified by a significant two-way interaction for stimulus by condition, *F*(1, 18) = 17.3, *p* = .001, a marginal interaction for stimulus by direction, *F*(1, 18) = 3.9, *p* = .063, and a marginal three-way interaction between all main effects, *F*(1, 18) = 4.3, *p* = .052.

A further analysis for the face data showed significant main effects for condition, *F*(1, 18) = 22.4, *p* = .001, and gaze direction, *F*(1, 18) = 9.5, *p* = .006, and a significant interaction between condition and gaze direction, *F*(1, 18) = 6.8, *p* = .017. Post hoc *t*−tests (paired samples) showed larger SCRs to straight (*M* = 0.63, *SE* = 0.13) than averted (*M* = 0.36, *SE* = 0.10) gaze in the live condition, *t*(18) = 3.34, *p* = .004, but not in the picture condition (*p* > .1). For the control stimulus, the analysis showed a non-significant trend of condition, *F*(1, 18) = 3.72, *p* = .07, reflecting greater responses in live (*M* = 0.124, *SE* = 0.052) versus picture (*M* = 0.034, *SE* = 0.017) condition. However, no other effects or interactions attained significance with the control stimulus (all *p*s > .1).

FACE CONDITION



RADIO CONDITION

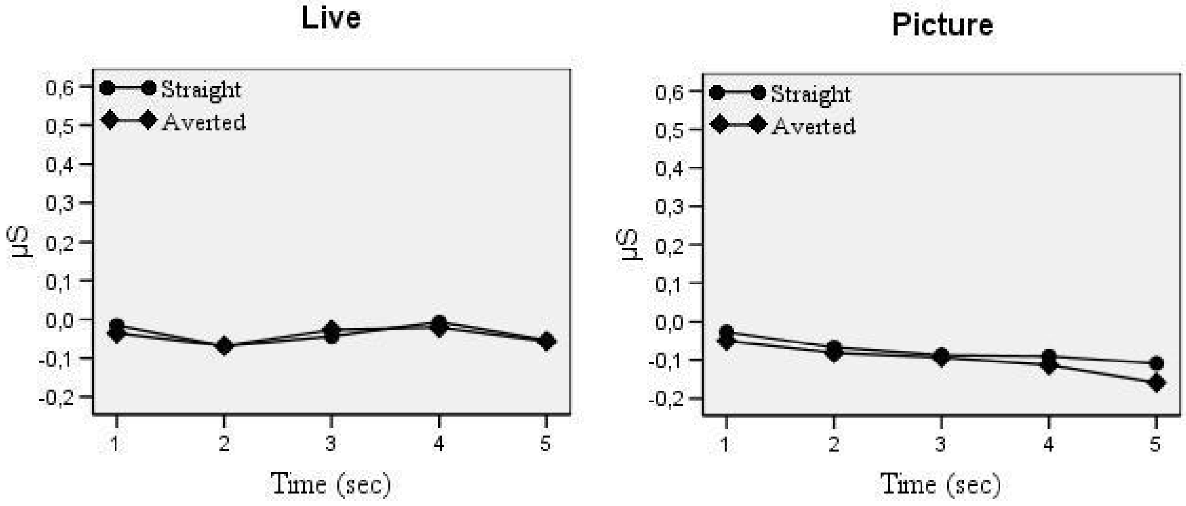


Figure 2. Mean skin conductance response to straight and averted direction during a 5-s stimulus presentation period: (i) live and (ii) computer presentation stimuli. Upper figures: Face condition; lower figures: Control condition.

The SAM ratings for pleasantness in different conditions were analyzed using a three-way analysis of variance (see Table 2.). The analysis revealed a marginally significant main effect for direction, $F(1, 18) = 3.89$, $p = .064$, and significant two-way interactions for stimulus and condition, $F(1, 18) = 6.6$, $p = .019$, stimulus and direction, $F(1, 18) = 12.33$, $p = .002$, and condition and direction, $F(1, 18) = 19.94$, $p = .001$. The three-way interaction, however, failed to reach significance ($p > .1$). Further analysis for the face stimulus conditions indicated a significant main effect of direction $F(1, 18) = 9.87$, $p = .006$, and an interaction effect between condition and direction, $F(1, 18) = 12.36$, $p = .002$. The interaction effect arose from lower subjective evaluations of pleasantness in the live condition to straight ($M = 5.47$, $SE = 0.474$) than to averted gaze ($M = 6.79$, $SE = 0.321$), ($t(18) = 4.05$, $p = .001$). In the picture condition, no significant effect of direction was found ($t < 1$, ns). With the control stimuli, the condition effect yielded a significant effect, $F(1, 18) = 8.05$, $p = .011$, indicating higher pleasantness scores in the live condition. However, no other effects or interactions were found with the control stimuli.

A three-way analysis of variance was performed on the SAM arousal scores. All main effects (all ps < .05), two-way interaction effects (all ps < .001), as well as the three-way interaction effect $F(1, 18) = 4.75$, $p = .043$, reached significance. The breakdown of the three-way interaction effect revealed that the self-reported arousal scores to face stimuli were significantly larger in the live condition to straight ($M = 5.00$, $SE = 0.426$) than averted ($M = 3.42$, $SE = 0.407$) gaze, $t(18) = 7.63$, $p = .001$. By contrast, SAM arousal scores did not differ between straight and averted gaze in the picture condition ($t < 1$, ns). No significant effects on arousal scores were obtained with the control stimuli (all ps > .1).

Table 2. Mean SAM-ratings (and standard errors of mean) for valence and arousal as a function of stimulus presentation condition and direction for i) face and ii) control stimuli.

Face	Live		Picture	
	Direct	Averted	Direct	Averted
Valence	5.47 (0.47)	6.79 (0.32)	6.26 (0.30)	6.47 (0.28)
Arousal	5.00 (0.43)	3.42 (0.41)	3.00 (0.40)	2.84 (0.38)
Control	Live		Picture	
	Direct	Averted	Direct	Averted
Valence	6.42 (0.38)	6.47 (0.41)	5.58 (0.41)	5.32 (0.43)
Arousal	2.89 (0.37)	3.16 (0.43)	2.84 (0.40)	2.68 (0.33)

Note. Valence: *1 = very unpleasant*; *5 = neutral, 9 = very pleasant*. Arousal: *1 = very calm*; *5 = neutral, 9 = very aroused*

In order to compare the subjective and physiological measures of arousal, scores on the SAM arousal scale were correlated with skin conductance responses. There was a non-significant negative correlation between the SAM arousal scores and SCRs for the live straight gaze condition ($r = -.34, p > .1$) and a marginally significant negative correlation in the live averted gaze ($r = -.39$, $p = .1$) condition. For the purpose of minimizing the effect of the participants' individual SC response and rating tendencies, difference scores between the straight and averted gaze conditions for physiological and self-report data were calculated in the live face condition. A scatter plot showing the two difference scores in Figure 3 illustrates the association between the two variables. A Pearson correlation coefficient computed between the self-reported and physiological arousal difference scores, although positive, was non-significant ($r = .27, p > .1, N = 19$).

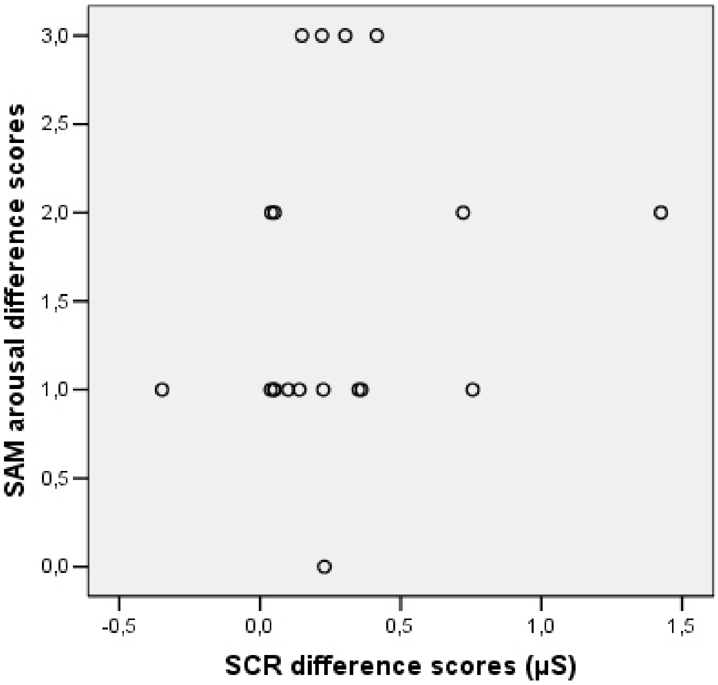


Figure 3. A scatter plot between SAM arousal difference scores (*M* = 1.58, *SE* = 0.21) and physiological arousal difference scores (*M* = 0.28, *SE* = 0.09) in the live face condition (*r* = .27, ns).

4. DISCUSSION

This study tested the predictions that in a nonselected population, direct gaze produces greater arousal than averted gaze, and that this effect is more evident with live stimuli as compared to picture stimuli presented on a computer screen. The effect of direction was assumed to limit to gaze direction, i.e. to be present with face but not with control stimuli. As well as assessing physiological arousal changes elicited by different gaze directions, we were interested in examining participants' subjective experiences of pleasantness and arousal associated with each condition. The final hypothesis predicted a relation between self-reported levels of experienced arousal and the observed levels of skin conductance responses.

The first two hypotheses were confirmed to the extent that direct gaze resulted in greater skin conductance responses than averted gaze only in the live condition; the effect was altogether absent in the picture condition. Faces in general, when compared to control stimuli, were associated with significantly stronger SCRs. With the control stimuli, a non-significant trend of live condition eliciting greater responses than picture condition emerged. However, no other effects or interactions attained significance with the control stimulus.

The results of the present study support the notion that straight gaze, which enables eye contact, produces greater SCRs, and thus greater arousal than unreciprocated gaze. Humans are believed to have a specialized neural system for gaze discrimination, and Baron-Cohen (1995) has named this cognitive module the Eye Direction Detector (EDD). Other researchers have suggested that the conscious feeling of being looked at and the more automatic process of gaze detection may represent different, yet probably interdependent functions of the EDD module (Franck et al., 1998). Thus, it is possible that the arousing effect of eye contact, also observed in the present study, may result from straight gaze eliciting the conscious feeling of being looked at and activating different function of the EDD system than averted gaze.

In this study, the gaze direction effect with face stimuli was, however, only present in the live condition. Hence, the results are consistent both with the findings of McBride and his colleagues (1965) and Nichols and Champness (1971) who used live confederates and reported greater SCRs to eye contact than to unreciprocated gaze, as well as with the findings of Leavitt and Donovan (1979), who reported no differences on SCR in mothers who viewed pictures of gazing and non-gazing infants on a television monitor.

One possible explanation for these findings is that pictorial stimuli are not sufficient to produce the conscious feeling of being looked at, i.e. the requirement of reciprocity, the need of mutual gaze to be experienced transactionally, is not met. Although Lang et al. (1993) have suggested that pictorial stimuli can activate cognitive representations of real objects and associated emotional responses that, in turn, can trigger visceral motility including changes in skin conductance, one can argue that in the case of studying reactions to eye contact, the veritable real-life stimuli is necessary. Wicker et al. (1998) conducted PET studies investigating brain regions involved in mutual versus averted gaze with videotaped stimuli, and concluded that videotaped scene of mutual gaze did not elicit an intense psychic experience of eye contact or “meeting of minds” found in natural face-to-face encounter. In the present study, similarly, the effects would not have been obtained if only computerized stimuli were used.

Furthermore, Patterson et al. (1981) have suggested that the changes in arousal are not elicited purely by another person’s gaze but that the interpretation of the social context also contributes to this process. Therefore, the gaze direction effect in the live but not in the picture condition may result from the pictures being unable to provide a social context, which in turn can be experienced as a lack of reciprocity. However, in the present study the subjects had an approximately 30 minutes of contact with the experimenters prior to the actual experiment, and hence the faces used as stimuli in both live and picture conditions had already gained a social significance as “experimenters”.

As noted before, SCR indicates emotional responding without revealing the valence of the response (Cook et al., 1991), and a gaze can be understood as a nonspesific activator, and as such may function as a stimulus either to be approached or to be avoided, depending on the context (Ellsworth & Langer, 1976). The picture condition, which may not sufficiently provide a social context to the faces, may subsequently fail to elicit emotional responding and activate behavioral motivational tendencies.

The findings of this study also support the conception of straight gazing faces having special stimulus value when compared to other objects, as was demonstrated in a previous study comparing SCRs elicited by a face and a paper cup (see Hirstein et al., 2001). In the present study the control stimuli were more complex and had more visual details than a paper cup (e.g. speakers of the radio roughly resembling the position of eyes, see Figure 1.), and thus had more in common with faces on the low level visual properties. Hence, the different responses to face and control stimuli are more likely to be due to differences in psychological significance as opposed to visual complexity (see also, Fowles, 1986).

The limbic-autonomic network is believed to be responsible for attaching a sense of value to different percepts, concepts or thoughts (see e.g. Hirstein et al., 2001). Amygdala, in particular, is believed to have a role in the establishment of sensory-affective associations and in the production of emotional responses that can be measured with SCRs (see e.g. Bechara et al., 1995). Concerning face stimuli, amygdala activation has been found to be greater during periods when direct gaze never occurs than during periods when direct gaze occurs on 40% of the trials. Consequently, amygdala activity is proposed to be heightened when a person is vigilantly waiting for the social contact of direct gaze to happen momentarily, instead of during the experience of eye contact per se (Hooker et al., 2003).

The gender effect as demonstrated by McBride et al. (1965) was not replicated in the present study. It should be noted however, that only female faces were used as stimuli in this study, and thus precaution should be used when deriving conclusions of gender effects and gaze direction on arousal, based on the present experiment. For example, the Donovan and Leavitt's (1980) observation of male faces eliciting greater arousal on both females and males could not be retested.

In the present study participants' subjective experiences during each condition were measured on two attributes: arousal and emotional valence. Models of emotional experience have usually described different emotional states with these two factors, although some models have proposed a greater number of dimensions (see e.g. Smith & Ellsworth, 1985). Lang et al. (1993) reported significant covariation between skin conductance magnitude and self-reported ratings of arousal, as well as between facial expressions and ratings of valence, and interpreted this consistency between evaluative judgments and physiological responses as evidence for organization of emotion in terms of these motivational parameters. In addition, valence and arousal are believed to define a general disposition to approach or avoid stimulation, as well as the vigor of this tendency (see Lang et al., 1993). In a previous EEG asymmetry study, however, motivational approach or withdrawal response was found to act somewhat separately from the affective valence, i.e. approach-related motivational tendency with negative affective valence (dispositional anger) was associated with activation of the brain regions specialized for approach processes (Harmon-Jones & Allen, 1998).

In the present experiment, the subjective evaluations of pleasantness were lower to straight gaze than to averted gaze in the live condition. However, it should be noted that the mean rating of pleasantness of the live straight gaze was slightly positive. The self-reported arousal scores in the live condition to face stimuli were significantly larger to straight than to averted gaze. Still, correlations between individual SCRs and ratings of arousal in the live face condition were negative and yielded non-significance, both for straight and averted gaze. An association between the difference scores, that were calculated in order to eliminate the effect of participants' SC response and rating tendencies, although positive, was non-significant. A larger sample size might have helped to clarify these findings.

Even though the use of a liquid crystal (LC) shutter can minimize the problems related to accurate control of parameters such as onset, spontaneity and duration of the stimuli, in the presentation of live stimuli, it does pose a question of consistency of facial expressions and possible blinking of the eyes. In the present study the experimenters' self-reported blinks were recorded, and the occurrence of the trials with a blink was 3.7 % (8 trials) of the data included in the final analysis. This number of blinks is unlikely to have significantly affected the results. In addition, all other nonverbal cues, including facial expressions, were kept as neutral as possible. However, observers are usually more aware of the nonverbal behaviors of their interaction partner, than the partners themselves, and the psychological importance of nonverbal behavior is indeed based on the assumption that it tends to be involuntary or overlearned and out of awareness. In addition, it has been suggested that emotions are conveyed in various channels, including posture and eyebrows (see Keltner & Shiota, 2003). Thus, the experimenter's ability to control these subtle variables, potentially indicating some emotion, can be placed under question. In further studies some method of control in order to assess the experimenter's neutral expression and blinks as well as participants' gaze behavior during the live conditions might be beneficial.

The duration of the gaze may also affect the reactions it elicits. The present study employed five second stimulus presentation periods which are still rather natural, although mutual gaze, without blinking, seldom lasts longer than a couple of seconds, especially between strangers in the natural interactions. It can be considered whether the 5-s direct gaze exceeded the limits of comfort or appropriateness and turned into a disturbing stare in the minds of the participants. The direct gaze combined with neutral expression may even have come across as threatening to some participants. The straight gaze in live-face condition, in addition to producing changes in a physiological arousal, was indeed, as noted before, associated with decreases in the SAM pleasantness scores as well as increases in the SAM arousal scores. With the control object, the live condition produced significantly larger SAM pleasantness scores than the picture condition. This could be interpreted in a way that people prefer to watch live stimuli as long as it does not exceed comfortable limits of producing arousal changes. The lower pleasantness scores to the direct gaze as compared to averted gaze for face stimuli in the live condition may indicate that the physiological responses were labeled more negatively (see Patterson, 1976), possibly due to factors in the experimental situation, or the arousal changes may have exceeded the limits of comfort resulting in more negative appraisal.

The present study aimed to compare SCRs to pictures presented on a computer screen and to live presentations of another person’s direct and averted gaze, in order to clarify previous partly inconsistent findings of the arousal effect of eye contact. These objectives were met in a sense that eye contact was found to elicit greater arousal than unreciprocated gaze when studied with live face stimuli but not with picture stimuli, and also possible explanations were introduced. The present findings support the idea of previous discrepant findings resulting from the varying use of live faces and pictures of faces as stimuli.

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