

**THE EFFECT OF THE MENTAL-STATE ATTRIBUTION OF GAZE AS “SEEING”  
ON AUTONOMIC AROUSAL RESPONSES TO GAZE CUES**  
**The mediating roles of self-awareness and presence**

**University of Tampere  
School of Social Sciences and Humanities  
A Pro Gradu thesis in Psychology  
Maija Arponen  
August 2012**

TAMPEREEN YLIOPISTO

Yhteiskunta- ja kulttuuritieteiden yksikkö

ARPONEN, MAIJA: The effect of the mental-state attribution of gaze as “seeing” on autonomic arousal responses to gaze cues: The mediating roles of self-awareness and presence

Pro gradu -tutkielma, 45s., 2 liites.

Ohjaaja: Jari Hietanen

Psykologia

Elokuu 2012

---

At times perceiving direct gaze causes higher autonomic arousal than perceiving averted gaze. Such different responses—notably found between face-to-face and pictorial gaze—have been suggested to be caused by attributing a live gazer with the ability to see: The direct gaze of a live onlooker may cause people to think that they are seen and heighten autonomic arousal. Being seen has also been linked with changes in self-awareness. We wanted to examine if the thought of being seen paired with a direct gaze would intensify autonomic activation and heighten subjectively reported self-awareness and arousal when compared to averted gaze and not being seen. To separate live gazing stimuli from the ability to see we used live-feed of a face on a television screen, and varied the reciprocity of a video link. The participants could see the face of the model in both conditions, but the model was claimed to be able to see them only in the reciprocal condition.

Autonomic skin conductivity responses (SCR) and self-report data on arousal, self-awareness and social presence from 18 healthy adult participants were analyzed with robust modern methods. Contrary to expectations, psychophysiological arousal did not accompany the mental-state attribution of gaze as “seeing”: Neither the main effect of the reciprocity of the video link nor the main effect of gaze direction nor the interaction between them was statistically significant. Nevertheless self-reported arousal heightened to reciprocal gaze in comparison with nonreciprocal gaze, as subjective ratings of emotional arousal showed a main effect for the presence of the reciprocal link. Gaze direction, however, did not significantly affect self-reported arousal and there was no interaction between gaze direction and reciprocity. Nonetheless the locus of awareness was affected by the mental attribution of gaze as seeing: The reciprocity of the link significantly heightened self-reported public self-awareness and the nonreciprocity of the link significantly heightened self-reported awareness of the environment. Neither gaze direction nor the reciprocity of the video link had an effect on either self-reported valence or felt social presence.

According to our results the mental attribution of being seen does not have an effect on arousal, but it makes people focus on themselves and changes the way they perceive their arousal state. Previously reported larger autonomic responses to direct gaze than averted gaze are suggested to capture the affective significance of both physical and social presence and be further affected by adequacy judgments. Effects of stimulus mediation through a video-link are discussed. Further research is called for to confirm the results and to better understand how these factors may modulate autonomic arousal when perceiving gaze.

**KEY WORDS:** Eye contact, gaze direction, skin conductance responses, SCR, mental attributions, public self-awareness, presence

**Acknowledgments**

The experiment was part of a gaze research project at the Human Information Processing - laboratory. It was conducted together with PhD, professor Jari Hietanen, PhD student Laura Pönkänen, PhD student Mikko Peltola, and M.A.(Psychology) Teemu Hallikainen, who worked as the other experimenter collecting the measurements. His master's thesis (2012) is based on the collected EEG-asymmetry data.

I would like to thank University lecturer, PsM Jari Lipsanen from the University of Helsinki for his interest and aid in all things statistic and Masters of Clinical Psychology/PhD student David Erseg-Hurn from the University of Western Australia for help on robust statistics.

# Table of Contents

Introduction .....	2
Gaze and arousal.....	2
Gaze and mental attributions leading to self-awareness .....	5
Self-awareness .....	6
Presence.....	8
The present study: The effect of the mental-state attribution of gaze as seeing on arousal responses .....	9
Materials and methods.....	12
Participants .....	12
Stimuli .....	12
Experimental procedure.....	13
Data analysis.....	15
Results .....	17
Skin conductivity results .....	17
Self-report data .....	18
Discussion .....	21
A summary of findings .....	21
Autonomic arousal.....	21
Self-awareness and arousal.....	22
Video-mediation .....	24
Social presence .....	27
Physical presence.....	27
Methodological issues and limitations of the study.....	29
The strength of experimental demands and comparatively higher pre-experimental arousal .....	29
Obtaining and analyzing the data .....	30
Conclusions .....	32
Bibliography .....	36

# Introduction

Processing the gaze of another person has widely been thought to work through bottom-up processes based on analyzing feature salience, but it has been recently suggested that it may also be modulated, top-down, by mental attributions (Teufel, Flecher, & Davis, 2010). Gaze is an element of nonverbal communication fundamental for social interaction (e.g. Argyle & Cook, 1976; Emery, 2000; Kleinke, 1986). It serves both the integrational functions of affirming mutual attention and responsiveness through rapid attention orientation and the interactive function of conveying interpersonal attitudes by elaborate inferences on the mental state of other sentient beings (e.g. Argyle, 1969; Kendon, 1967). As suggested by Argyle (1969), it seems information from *proxemics* (spatial behavior), posture and facial expressions is processed jointly with gaze (e.g. Langton, 2000; Lobmaier & Perrett 2011; Tipper, 2010). Indeed, processing gaze seems to be attuned by the presence of other individuals to the information most useful for social interaction (Foulsham, Cheng, Tracy, Henrich, & Kingstone, 2010).

In direct support of top-down modulation of social gaze perception it has recently been shown that directing social attention by gaze cues might be controlled by voluntary mechanisms (Vecera & Rizzo, 2006). For instance the mental state attribution of the gazer as “seeing” has been shown to affect rapid attention orientation by gaze cues (Teufel, Alexis, Clayton, & Davis, 2010). The mental attribution of being seen is also fundamental for heightened self-awareness (e.g. Feningstein, Scheier & Buss, 1975), a state widely associated with autonomic arousal to gaze cues (e.g. Carver & Scheier, 1981).

## Gaze and arousal

The intimacy equilibrium model (Argyle, 1976; Argyle & Dean, 1965) and Patterson's (1976) arousal model of interpersonal intimacy hold eye-contact as a central variable controlled by humans to maintain or change their arousal level during social interaction. Patterson's (1976) arousal model proposes that in an interaction situation, changes in one person's intimacy behaviors (e.g., eye contact) precipitate an arousal change in the other person. The cognitive appraisal of the arousal change as emotionally positive or negative leads to either enhanced or compensatory reactions aimed to maximize comfort (Patterson, 1976). If compensatory mechanisms, such as movement towards or away from the subject are blocked, arousal may heighten further (Argyle & Dean, 1965). Although many of the numerous studies aimed at understanding social gaze rely on these theories, the effects of gaze perception on autonomic arousal has not received a lot of attention. The limited number of studies researching the problem use different indices of autonomic arousal and give conflicting results.

*Electrodermal arousal* (EDA) can be thought to measure affective intensity regardless of valence (Bradley, Codispoti, Cuthbert, & Lang, 2001; Lang, Greenwald, Bradley, & Hamm, 1993). Because of this it may be a good measurement to use in gaze research, as it has been suggested that gaze communicates the intensity of feelings (Kimble, Forte, & Yoshikawa, 1981) quite independently of valence (Cook, Hawk, Davis, & Stevenson, 1991). Autonomic electrodermal arousal responses are created when sweat secretion changes the electrical properties of the skin (e.g. Sato, 1977). When regarded as a marker of general arousal, the EDA is seen as a sensitive index of emotion-related sympathetic activity (Dawson, Schell & Filion, 2007). It reflects the outcomes of processing emotional stimuli and can be used as a tool to explore emotional components of mind-body-mind relationships (Sequiera, Hot, Silvert, & Delplanque, 2009). Rapid and transient skin conductivity responses (SCR) have been shown to directly represent the amount of neural activation by their frequency and amplitude (Macefield & Wallin, 1996; Bini, Hagebarth, Mynninen, & Wallin, 1980; Sugeno, Iwase, Mano, & Ogawa, 1990).

It is under dispute, however, whether electrodermal responding is a marker of general psychophysiological and motivational arousal (e.g. Lindsley, Knowles, & Magoun, 1950; Duffy, 1951; Sequiera et al., 2009), or an indicator of behavioral inhibition common in the context of encountering novel environmental stimuli (Fowles, 1980, 1986; Tranel, 1983; Gray, 2007). In the brain, all emotive electrodermal responding seems to rely on the amygdala (see Critchley, 2005, review) and higher cortical functioning (Bechara, Tranel, Damasio, & Damasio, 1996; Naqvi & Bechara, 2006; Tranel 2000; Zahn, Grafman & Tranel, 1999), but motor orienting responses may have another route that bypasses these (Nagai, Critchley, Featherstone, Trimble, & Dolan, 2004). EDA and emotional intensity have been linked irrespectively of emotional valence (Bradley et al., 2001; Lang et al., 1993). Thus it seems that emotion related EDA is an indicator of nonspecifically valenced arousal states, depends on mentalization, but may include a simultaneous automatic analysis of environmental novelty value through another cerebral route. This suggests that electrodermal responding is a marker of psychophysiological arousal apt to capture significant changes in gaze related arousal.

Why perceiving direct gaze at times affects autonomic arousal is unclear. It is widely known that gaze functions as a cue that interaction will take place, and it has been previously hypothesized that perceiving a communicative intent would be the reason behind it (Argyle & Cook, 1976). Indeed, Kampe, Frith and Frith (2003) were able to show that such an intention to communicate is automatically recognized when seeing pictorial, dynamically moving direct gaze; Pictures of direct gaze activate brain regions in a similar way as hearing your own name. Kampe et al. also measured autonomic arousal responses at the same time, but did not find them to heighten in response to direct gaze when compared with averted gaze. The automatic recognition of an intention to

communicate may still contribute to the attribution that modulates psychophysiological arousal: Hietanen, Leppänen, Peltola, Linna-aho and Ruuhiala (2008) as well as Pönkänen, Peltola and Hietanen (2011) found autonomic arousal to heighten in response to direct gaze in comparison with averted gaze when using live stimuli. They suggested that the key to gaze related arousal responses is in being the object of the attention of another living person.

Hietanen et al. (2008), Pönkänen et al. (2011) and Helminen, Kaasinen and Hietanen (2011) suggested that the previous inconsistencies in results when researching autonomic responses to seeing another person's direct gaze vs. averted gaze could be caused by the presentation mode of the stimuli. In most studies reporting enhanced arousal to direct gaze the stimulus was presented face-to-face. They also remarked that in most studies reporting no differentiation between gaze cues by autonomic arousal, like that of Kampe et al. (2003), the face stimuli were presented as pictures on a TV monitor or a computer screen. Hietanen et al. compared skin conductance responses of when participants were looking at images of faces on a computer screen to seeing a live person's face through a computer-controlled liquid crystal shutter. They did not find gaze direction to have an effect on autonomic arousal when the participants looked at pictures, but when the participants were presented with a face-to-face condition the autonomic responses were significantly larger to direct gaze than to averted gaze.

The use of live or interactive stimuli as opposed to pictorial or passive stimuli has been suggested to modulate arousal effects also previously (e.g. Martin & Gardner, 1979). However, even pictorial stimuli and video recordings have produced conflicting results on the effects of gaze direction on psychophysiological markers of arousal. There have been studies using pictorial or video-recordings, which have found healthy subjects not to show arousal effects of gaze direction on skin conductivity responses (Donovan & Leavitt, 1980; Leavitt & Donovan, 1979; Kylliäinen and Hietanen, 2006). By contrast, Conty et al., (2010) found an increase in electrodermal arousal to pictorial stimuli of direct gaze as compared to averted gaze or closed eyes while attention was allocated to a difficult task.

Live situations and moving, dynamic pictorial stimuli have also provided conflicting results. Heart rate increases in response to direct gaze vs. averted gaze both in live, interactive situations (Kleinke & Pohlen, 1971) and when using pictorial stimuli with moving, dynamic eye gaze behavior (Wieser, Pauli, Alpers, & Mühlberger, 2009). However, pictorial stimuli with moving, dynamic eye gaze behavior did not result in higher autonomic arousal to direct gaze than averted gaze, when pupil size was used as an arousal measure (Kampe et al. 2003). Results based on EEG alpha arousal are conflicting, with some studies using interactive stimuli creating an effect (Gale et al., 1972, 1975), but noninteractive live situations creating no effect (Martin & Gardner, 1979). In studies using SCR as an index greater responses to direct than averted gaze have been obtained in

live situations regardless of the interactivity of the situation (Helminen 2011; Hietanen et al., 2008; McBride, King, & James, 1965; Nichols & Champness, 1971; Pönkänen et al., 2010).

These results are not consistent even between studies using the same index and classed by presentation mode. Thus it seems that other causes than whether the stimulus is pictorial or presented face-to-face modulate whether autonomic arousal responses differ between direct and averted gaze cues. It could be that mental-state attributions, integral for the social aspect of gaze, mediate arousal responses.

## **Gaze and mental attributions leading to self-awareness**

Self-awareness is formed through a social context and it cannot be created without understanding the intentions of others. Intentions are often revealed by attention orientation, for which gaze is one of the best known nonverbal cues. Indeed, gaze direction is most often perceived in a spatial relation to the on-looker or other objects in the proximity. It is either *direct* or *averted*, or oriented towards something or nothing. We are extremely sensitive to gaze direction (Gamer & Hecht, 2007) and actually have an inborn ability to differentiate between direct and averted gaze (Farroni, Csibra, Simion, & Johnson, 2002). We understand the referential intent of gaze aimed at something from an early age (Caron, Kiel, Dayton, & Butler, 2002). Adults seem to have an enhanced representation of direct gaze, which leads to automatic and rapid detection of other individuals making eye contact (Hains & Muir, 1996; Stein, Senju, Peelen, & Sterzer, 2011).

The preference for direct gaze is thought to be formed due to the implication that the gazer is attending to you. A well-known example of this is seen in the conversational patterns of gazing, where the speaker is gazed at by the listener and the next speaker is identified by gaze. Averted gaze may even lead to feelings of neglect, because when someone is signaling interest towards targets in the nearby environment, they are not attending to you (Wirth, Sacco, Hugenberg, & Williams, 2010). Brain regions implied in mentalizing, or understanding the intentions of others, have been shown to become activated both when seeing direct gaze (Kampe et al., 2003; Wicker, Perrett, Baron-Cohen, & Decety, 2003) and averted gaze (Calder et al., 2002). More precisely, an intention to communicate is automatically recognized when seeing direct gaze (Kampe et al., 2003), irrespectively of the valence of the emotion of the addresser (Wicker et al., 2003). Interpreting the meaning of gazing behavior seems to depend on a multitude of social norms and cues, and whether or not they are shared by the gazer and on-looker (Adams, Franklin, Nelson, & Stevenson, 2011; Adams, Rule et al., 2010).

Heightened self-awareness has been associated with heightened arousal due to being the object of attention. The existence of self-awareness has been argued to rely on the internalization of a theory of mind and of a set of standards and rules of behavior: The self is evaluated and exists in



relation to these rules (e.g. Bischof-Köhler, 1991; Lewis, 2001; Zahn-Waxler, Radke-Yarrow, Wagner, & Chapman, 1992). In order to be formed, both a theory of mind and a set of social rules require the affective experience of “self-consciousness” created by an early experience that the self is an object others attend and relate to (see Reddy, 2003). Noticing that one is receiving attention can be achieved by the mutual attention provided by eye-contact, or “attention contact”, as it has been coined by Gomez (1994). As eye-contact facilitates the formation of self-awareness via self-consciousness and the internalization of a theory of mind, the emotional experience direct gaze produces might trigger self-awareness.

Being looked in the eyes holds a special meaning in the creation of self-awareness. It has been argued by Reddy (2003), that the reason behind the preference for direct gaze is an emotional experience formed by being the object of attention. It is of consequence that in relation to averted gaze we detect direct gaze faster (von Grünau & Anston, 1995; Senju, Hasegawa, & Tojo, 2005) and better (Conty, Tijus, Hugueville, Coelho, & George, 2006). According to Reddy (2003), appropriate responses to attention and actions aimed at establishing mutual gaze must mean that there is awareness both of the other's attention and of the orientation of attention towards the self. These experiences are essential in forming representations that enable awareness of the self and precede it (Reddy, 2003). This makes attention received by mutual gaze a key element in the creation and elicitation of self-awareness.

## **Self-awareness**

Wicklund (1975) presented an early theory of the functional nature of objective self-awareness: Firstly a stimulus that prompts seeing one's self as an object will create self-focused attention prompting self-evaluation. Secondly a judgement of inadequacy to stand up to perceived expectations leads either to behavioral adjustments to achieve them, or withdrawal from the evaluation-inducing situation. This dual nature of self-focus is generally agreed upon (e.g., Buss, 1980; Fenigstein, Scheier, & Buss, 1975) with recent theories stressing that both conditions contain both controlled and persistent, automatic forms of processing (see Silvia & Duval, 2001 for review).

Buss (1980) has differentiated between *private self-awareness*, which clarifies and intensifies momentarily important affects, motives and personal standards, and *public self-awareness* which is marked by the aforementioned need to please others in order to alleviate discomfort that rises from a feeling of being evaluated. These changes have been shown to affect behavior (for reviews, see Fejfar & Hoyle, 2000; Gibbons, 1990; Silvia & Duval, 2001). A full length mirror (e.g., Webb, Marsh, Schneiderman, & Davis, 1989) or a video camera (e.g., Alden, Teschuk, & Tee, 1992) can be used to induce public self-awareness. Instructions to focus on personal thoughts or feelings (e.g., Webb et al., 1989), writing tasks promoting individuation (Silvia & Eichstaedt, 2004) and the use of

a small mirror that reveals only the participant's head and shoulders (e.g., Govern & Marsch, 1997) cause private self-awareness.

The locus and amount of awareness can change from one moment to another. Govern and March (2001) have created a reliable scale for measuring *situational awareness*, consisting of private and public self-awareness together with *awareness of the environment*. Focusing attention outward to the environment may lead to effects on behavior that are contrary to self-awareness; the cognitive self ceases to exert control as the importance of the self and living up to public standards are no longer prominent (see Postmes & Spears, 1998 for review). The paradox of situational awareness is that increasing self-focus leads to a behavioral bias to heed to the interests of others, whereas focusing on the environment seems to lessen the motivation to act pro-socially (Ickes, Holloway, Stinson, & Hoodenpyle, 2006). It has been suggested that self-focus generally heightens responsiveness to internal states (Scheier & Carver, 1977), and in particular that it renders self-reports of arousal more accurate (Gibbons, Carver, Scheier, & Hormuth, 1979; Hansen, Hansen, & Crano, 1989). Silvia and Gendolla (2001), however, have proposed that self-focused attention does not enable accurate self-knowledge, but rather changes cognitions of the self.

Self-awareness is thought to heighten in the presence of an audience or regular mutual eye-contact (Carver & Scheier, 1981). Perceiving or believing that they are the object of gaze makes people feel that the gazer is attentive (Kelly, 1978; Kleinke, Bustos, Meeker, & Staneski, 1973; Kleinke, Staneski, & Berger, 1975), and just hearing that they have been looked at less than is normal makes people judge the other person as less attentive (Kleinke et al., 1973). As not looking at others during interaction indicates lack of interest and attention (Argyle, 1976), averted gaze has been found to evoke feelings of neglect (Wirth et al., 2010) which may heighten self-awareness.

Perceiving direct gaze or gaze aversion can lead to differing conclusions depending on situational cues: Both may lead to a judgement of inadequacy and heighten self-awareness. For example, if a gazer can see you better than you can see a gazer, awareness of a direct gaze may make you feel uncomfortable (Argyle, Lalljee, & Cook, 1968). This feeling of unease is a function of role and status, and is affected by being younger, female, an interviewee or in possession of certain attributes of personality (Argyle & Williams, 1969). These attributes of personality might be emotional stability and tendency to feel anxiety, which have been shown to affect responses to eye-contact (Wieser et al., 2009; Helminen et al., 2011). However, unease may also be produced by averted gaze: There is a cerebral response signaling failure to meet expectations if an attractive person looks away (Kampe, Frith, Dolan, & Frith, 2001). The judgement of inadequacy to live up to expectations may be behind the feeling of discomfort.

Psychophysiological arousal and a positive cognitive appraisal of emotions during heightened public self-awareness are also possible. Hietanen et al. (2008) found public self-awareness to

heighten in the presence of face-to-face direct gaze as compared to averted gaze and pictorial stimuli. Although an uncomfortable feeling usually accompanies a stress reaction associated with the feeling of being looked at (Rimmele & Lobmaier, 2012), Hietanen et al. found both positively valenced emotional arousal and heightened electrodermal arousal to face-to-face, direct gaze cues.

## **Presence**

In our daily lives we mostly respond to social cues in the face-to-face physical presence of other people who are alive, have a mind and who can see us. A lot of research on social gaze, however, uses pictures of people as stimuli in order to better control and replicate experimental procedures. It has often been suggested that human eye-contact and the direct gaze of nonsentient pictorial stimuli may produce different experiences (e.g. Argyle 1976; Wicker, Michel, Henaff, & Decety, 1998; Hietanen et al. 2008). By using mediated interaction, such as video-links, virtual realities and other forms of computer-mediated communication, an ability to connect with another's mind can be separated from physical presence. This social presence can be, and often is, combined with pictorial stimuli.

The social presence -framework has emerged as one of the main ways to conceptualize and measure a mediated sense of the other's presence (Biocca, Harms, & Burgoon, 2003; de Greef & IJsselsteijn, 2000; Rice, 1993; Short, William & Christie, 1976). Recent theories have defined it as the sense of "being with others" (Heeter, 1992) or more precisely a changeable amount of awareness of the presence of another sentient being and the ability to connect with another's mind (Biocca, Harms, & Gregg, 2001). The effects of such a presence have been widely researched in the field of communication studies, but have only lately gained importance in the fields of social psychology and gaze perception (Grayson & Monk, 2003).

Most theories and self-report questionnaires build upon Short, William and Christie's (1976) major theory which regards social presence to be a subjectively formed quality of the communication medium. It is presented as a single factor containing the capacity to transmit information about facial expressions, direction of looking, posture, dress and nonverbal vocal cues, representing a subjective "mental set" towards the medium in question. Sproull and Kiesler (1986) have explained the differences in felt social presence to pertain to the absence of social-context clues. In a face-to-face situation these cues are conveyed by nonverbal behavior, spatial features, artifacts, and physical adornments (Burgoon, Buller, & Woodall, 1989), and they define the nature of the social situation and the actors' relative status (Sproull & Kiesler 1986). They are reduced in mediated communication, because the number of sensory channels is cut and the possibilities of direct feedback decrease (Trevino, Lengel, & Daft, 1987). When cues lessen, people tend to be more self-absorbed than other-oriented, their social orientation of status lessens, and they behave in

a way that conforms less to social norms (Kiesler, Siegel, & McGuire, 1984; Siegel, Dubrovsky, Kiesler, & McGuire, 1986; Sproull & Kiesler, 1986).

Video-links are a form of mediated interaction that allows the use of a large number of audio-visual cues. It is widely held to be a communication medium high in both “media richness” and “social presence” and thought to engender a good sense of interaction quality. Despite of this, perceived and actual quality of interactivity in a video-mediated environment is generally known to be lower than in a face-to-face situation (e.g. Sellen, 1995; O'Malley, 1996). Reactions to live video-mediated material and recordings of a previous, but similar interaction situation are known to differ: There is greater activation in brain regions involved in social cognition and reward when using a live video-link (Redcay et al., 2010). People also prefer live video-links to recordings and can detect the contingency of behavior and correlate affect while they are used (e.g. Stormark & Braarud, 2004). Mediating live facial stimuli through a video-link affects interpersonal distance and nonverbal spatial communication—forms of behavior known to affect arousal responses—(McBride, King, & James, 1965; Llobera, Spanlang, Ruffini, & Slater, 2010), but it should not change gazing behavior if eye-contact is allowed (O'Malley, Langton, Anderson, Doherty-Sneddon, & Bruce, 1996). Thus video-mediation might reveal whether arousal responses to gazing stimuli can be induced independently of physical presence; by mental attributions.

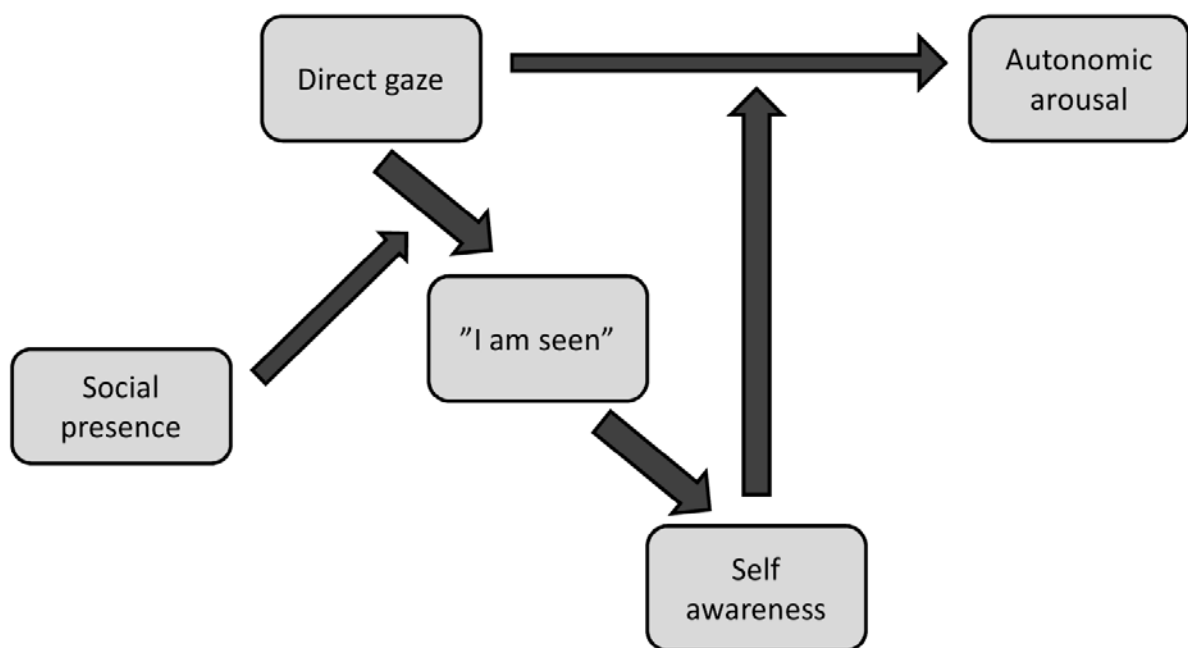
### **The present study: The effect of the mental-state attribution of gaze as seeing on arousal responses**

Hietanen et al. (2008) have suggested that the thought of being seen may modulate whether arousal responses differ between direct and averted gaze cues. They and Pönkänen et al. (2011) as well as Bailey, Chorosovic, White and White (1981) have found larger skin conductance responses to live faces than to pictures of faces, and to direct than averted live gaze. Hietanen et al. concluded that something in live faces in general, and faces with direct gaze in particular, elicits more intense autonomic activation than pictures of faces. As the direct gaze of a live face was also found to enhance reported self-awareness, they drew the conclusion that the heightening of both autonomic arousal and reported self-awareness was due to the mental attribution of the direct gaze as observing (Hietanen et al.2008; Pönkänen et al., 2011). The thought of being seen or not seen may explain why direct gaze has not been consistently found to cause higher autonomic arousal than averted gaze.

The mental attribution of being seen and gaze *per se*, however, have never been empirically differentiated in gaze research. Recent evidence shows that when using video-mediated stimuli such a separation of the mental-state attribution of gaze as seeing or nonseeing has an effect even on basic perceptual processes (Teufel, Alexis, et al. 2010). Thus it is conceivable that being gazed at

would elicit a different response depending on whether the person thinks she is being seen or not. Comparing responses to the same live stimuli in two conditions might help us distinguish between whether the arousal response to direct gaze is mediated through the mental attribution of being seen or whether it is a stimulus driven automatic response of the autonomic nervous system.

Moreover, even though self-awareness theory postulates that direct gaze makes one think of the way one is perceived by others, and thus heightens public self-awareness (Fenigstein, Scheier, & Buss, 1975), Hietanen et al.'s (2008) assumption that the mental attribution of being seen causes heightened self-awareness has not been previously empirically tested either. Furthermore, although heightened self-awareness has been suggested to be caused by or lead to heightened arousal (e.g. Carver & Scheier, 1981, Wegner & Giuliano, 1980) there are few, if any studies comparing the correlations of physiological and self-report arousal data across conditions where self-awareness has been manipulated. This is surprising, as self-awareness constructs based on arousal attribution theories are generally known to build upon the belief that heightened self-awareness leads to better perception of such internal states as arousal (Scheier & Carver, 1977).



**Figure 1.** The mental attribution of being seen may moderate autonomic arousal to direct gaze due to enhanced self-awareness.

We hypothesized that the reason why direct gaze can at times be found to heighten autonomic arousal would be the heightening of self-awareness resulting from the belief of being seen by a sentient other (See Figure 1). To test our assumption, we measured responses to seeing the gazing face of a live-streamed, mediated person presented on a television screen. In one situation, the mediated model was claimed to be able to see the participants through a reciprocal video-link. In

the other situation, the link was claimed to be nonreciprocal, so the mediated model could not see the participant. The facial stimulus was, as a visual cue, a two-dimensional picture, but held perceivable interactive potential, like a real person sitting in the same room. By presenting a live, immediate cue on a television screen, we tried to rule out the obvious differences between pictorial and face-to-face live cues. Thus we aimed to determine whether the mental state attribution of gaze as seeing and the thought of being seen have an effect on self-reported and psychophysiological responses independently of physical presence.

We hypothesized that by controlling the reciprocity of the link we would manipulate the mental attribution of being seen and that i) SCR responses to direct gaze cues would be larger than those to averted gaze cues only when paired with the mental state attribution of gaze as seeing. We also thought that gaze direction and the reciprocity of the video-link would have an effect on both ii) self-reported arousal and iii) valence responses. In addition, we anticipated that for direct gaze iv) the self-reported and autonomic arousal responses would be correlated and that the correlations would differ between the two conditions. We thought that the reciprocity of the link would have an effect on v) social presence and vi) self-awareness responses to direct gaze. Finally, we expected measures of vii) public self-awareness to correlate with autonomic arousal to direct gaze, with no change in correlations between the reciprocal and nonreciprocal conditions.

# Materials and methods

## Participants

The participants were 27 adults (20 females, 7 males, mean age=24.44 years, range 19–46 years) with normal or corrected-to-normal vision and with a reported limited acquaintance to video conference calls (e.g. Skype). None of the participants were previously known by the experimenters. The data from 10 participants were excluded after testing due to four different reasons: Technical error in data collection ( $n=5$ ), technical error in stimulus presentation ( $n=2$ ), and self-reported failure of the success of the central manipulation, i.e. disbelief of the *reciprocal condition* to be reciprocal ( $n=2$ ). In addition, the Situational Self-Awareness data were lost for one participant. Informed, written consent was obtained from all participants. The manipulation was explained to all participants after the experiment. The analysis is based on the data of 18 participants (15 females, 3 males, mean age=24.33 years, range 19–46 years).

## Stimuli

The facial stimuli were presented on a CRT television screen, situated in front of the participant, on a table, 5 cm behind a 40 cm x 30 cm liquid crystal (LC-TEC Displays Ab) shutter attached to a white frame. The participant was seated at a distance of 70 cm away from the frame. The transparency of the voltage-sensitive LC-shutter was controlled by Neuroscan Stim software (NeuroScan, El Paso, Texas, USA) running on a desktop computer. The presented stimulus was the face of a female experimenter collecting the data, live-streamed from another room through a video camera (Sony DCR-VX1000). The model tried to keep a neutral, motionless expression on her face and withhold from blinking. Gaze direction was either direct or averted 30° to the left or right. The facial stimulus was visible through the LC-shutter only when it turned briefly from an opaque to a transparent state during stimulus presentation. (See Picture 1)

The facial stimuli were presented in two conditions, reciprocal and nonreciprocal. In the reciprocal situation both a video camera (Logitech Quickcam) on top of the TV-screen and audio contact through microphones and loudspeakers were present. They were removed in the nonreciprocal condition. The loudspeaker carrying sound from the next room was hidden directly in front of the participant, under the table, and the microphone, carrying sound to the model directly to the right from the participant, was visible all the time.



Picture 1. The picture illustrates a reciprocal condition with direct gaze.

## **Experimental procedure**

On arrival the participants were told that the experiment concerned face perception in a videoconferencing situation. An informed consent was obtained. The participant was introduced to only one laboratory room and two experimenters, one male and one female. The experimenter that was going to be the model described the general procedure to the participant and spoke informally to maintain a relaxed atmosphere. The experimenters prepared the participant for skin conductance and EEG-measurements, the female experimenter performing the preparations that included direct physical contact. The participants were informed that the male experimenter, who stayed in the room with them, could not see them but was there to look after the testing equipment behind a separate screen.

For the skin conductance measurements, the electrodes (Ag/AgCl, diameter 8 mm) were covered with a layer of electrode gel and attached to the palmar surface of the medial phalanges of the index and middle fingers on the participant's left hand. The skin was cleaned with an antiseptic liquid and gently abraded with a wooden stick. The signal was acquired with an amplifier supplying constant-voltage AC excitation (22 mV) (ADInstruments). Power Lab 400 equipment was used for the SCR measurements and the data collection was controlled by Power Lab Chart v3.6 computer program



running on a Power Macintosh 7100/80 computer with a sampling rate of 100/s. The system was calibrated prior to each recording to detect activity in the range of 0-40  $\mu$ Mho.

The experiment was conducted in three parts, with data acquisition always consisting of two blocks of stimuli, one reciprocal and the other nonreciprocal. The experiment began with familiarization to reciprocal video-conferencing, which was followed by recording the physiological data in two blocks with 16 trials. In the third part self-evaluation data for perceived social presence (Salinäs, 2005), avoidance and approach behavior (SAM, Bradley & Lang, 1994) and amount of self-awareness (Situational Self-Awareness, Govern & Marsch, 2001) were collected in two blocks of 6 trials.

Participants were familiarized with interaction through the live audio-visual streams by a short structured interview conducted by the model. They were asked if they could see the model; if the model was situated in the middle of the screen; if not, they were requested to signal the wanted direction; whether they had previously participated in psychological testing; if yes, what kind and when; and about their previous experience with video conference calls (MSN, Skype). After the interview the female experimenter returned to the laboratory room in order to instruct the participant to remain as still as possible during the trials and to report the direction of the gaze (straight, left, right) aloud after the shutter had turned opaque.

The facial stimuli for the physiological data were presented in two blocks of 16 trials. The presentation order of the direct and averted trials (eight trials each) was pseudorandom (no more than two consecutive trials of the same type). As SCR habituates quickly, two pseudorandom scripts were used to control that the number of straight and averted gaze stimuli was not disproportionately weighted over time (Appendix 1). Each trial lasted for 5 s, after which the shutter remained opaque during a randomly varied interstimulus time of 20-30 s. The presentation of facial stimuli was cued 8 s earlier by a faint, short audio signal presented through two pairs of speakers. To ensure that the participants attended to the eyes of the model during stimulus presentation, they were given a task to perform during the experiment: Every time the shutter turned opaque after the presentation of the stimulus, they were to state out loud the gaze direction they had seen (straight, right or left).

The blocks were presented with a short pause between them and the order of the presentation mode (camera present and audio stream on/camera absent and audio stream off) was counterbalanced across the participants. Before each block, the model entered the laboratory room and either removed or placed the video camera on top of the television and turned the audio equipment on or off while saying “Now you will see me and hear me, and I will see you and hear you.” or “Now you will see me but not hear me, and I will not see you or hear you.” The shutter was left open until the participant could see the female experimenter on the television screen. A

small interaction followed: The female experimenter asked if her face was still at the center of the screen, and when there was no audio- or visual contact, waved and said something aloud.

The self-report data of assessing the participants' feelings of affective valence and arousal, self-awareness and felt social presence were collected during the two final blocks. The same order was followed for the presence of the camera as in the 16 trial blocks. The first two trials consisted of a direct and an averted gaze, followed by four direct gazes. The participants were given 7 sheets of paper and instructed by the male experimenter to fill one sheet per trial, always after the shutter was closed, then to read the next sheet, and signal their readiness verbally. All sheets pertaining to one scale were handed out at the same time, and if needed, the way to fill them was further instructed by the male experimenter. The first two sheets contained two 9-point Self-Assessment Manikin (SAM) scales (Bradley & Lang, 1994). The participants completed the valence and arousal ratings (in this order) for the presented stimuli: Averted and direct gaze, with and without a video-link. For the three-sheet Situational Self-Awareness -scale (Govern & Marsch, 2001) and one sheet felt social presence in telecommunication -scale (Salinäs, 2005), ratings were completed only for a direct gaze. The shutter was always opened by the male experimenter after the participant verbally affirmed that a self-assessment sheet was finished. The presentation of facial stimuli was again cued 8 s earlier by a faint and short audio signal presented through two pairs of speakers. The participants finished the experiment by filling in a sheet of paper with open ended questions about what they thought the experiment had been about and what thoughts or feelings it had raised in them.

## **Data analysis**

The magnitude of the skin conductance response (SCR) was measured within a 4 s time period, after 1 s from stimulus onset, as the maximum rise from the baseline level of skin conductance at the time of the stimulus onset. Trials were rejected on four bases: i) If an amplitude change of more than 0.1  $\mu\text{Mho}$  occurred within the first second after the facial stimulus was presented, the trial was rejected ( $n=22$ ), because the response could have originated for another, earlier reason (Dawson et al., 2000). Other reasons for trial rejection were ii) steeply sinking pre-stimulus skin conductivity responses that might hide a reaction ( $n=7$ ), or iii) steeply increasing pre-stimulus skin conductivity responses, resulting in a high baseline value at stimulus onset and negative response values ( $n=32$ ), iv) blinking ( $n=29$ ) or other observable movement of the model ( $n=4$ ). The female experimenter kept a record of her own blinks and movements during the experiment. The percentages of rejected trials in the different conditions were the following: reciprocal direct gaze 33 %; reciprocal averted gaze 23 %; nonreciprocal direct gaze 38 %; and nonreciprocal averted gaze 35 %.

The participants (n=17) were asked to complete a questionnaire containing the Situational Self-Awareness Scale (SSAS, Govern & Marsch, 2001) for direct gaze in the reciprocal and nonreciprocal situations. The SSAS consists of nine items accompanied by seven-point scales ranging from 1 (*strongly disagree*) to 7 (*strongly agree*). Three items measure *public self-awareness* (e.g., "I am concerned about the way I present myself right now"), three items measure *private self-awareness* (e.g., "I am conscious of my inner feelings right now"), and three items measure "awareness of immediate surroundings" (e.g., "I am keenly aware of everything in my environment right now").

Modern robust methods fit for dealing with nonnormality, small samples sizes and unequal variances (Wilcox, 2011; Wilcox, 2012) were used where data was not parametric. Testing for the equality of variance was not found applicable, as classical tests of equality of variance assume normality although it is normal for both inequality of variances and nonnormality to occur at the same time (Bradley, 1980; Keppel & Wickens, 2004). Modern robust methods were chosen; despite of the persistence of a robustness argument, classical methods like the ANOVA, have been proven by several hundreds of papers not to be robust under the violation of two or more assumptions (for reviews see e.g. Bradley, 1978; Erseg-Hurn, 2008; Harwell, Rubinstein, Hayes, & Olds, 1992; Wilcox, 2011). The consensus in the literature is also that Rank Transformations (Conover & Iman, 1981) should not be used (For reviews on problems see Blair & Higgins, 1985; Fahoome & Sawilowsky, 2000; Sawilowsky, 1990; Toothaker & Newman, 1994). The use of transformations was ruled out as it is problematic for numerous reasons, including failure to restore normality and homoscedasticity, and an inability to deal with outliers (Grissom, 2000; Leech & Onwuegbuzie, 2002; Lix, Keselman, & Keselman, 1996).

The statistical analyses were performed with IBM SPSS Statistics 18 (spss.exe, version 18, 2010), R (R.app, version 19, 2011) and the effect size -program for educational and psychological measurement of Angina, Keselman and Penfield (ESBootstrapCorrelated3.exe, 2005).

# Results

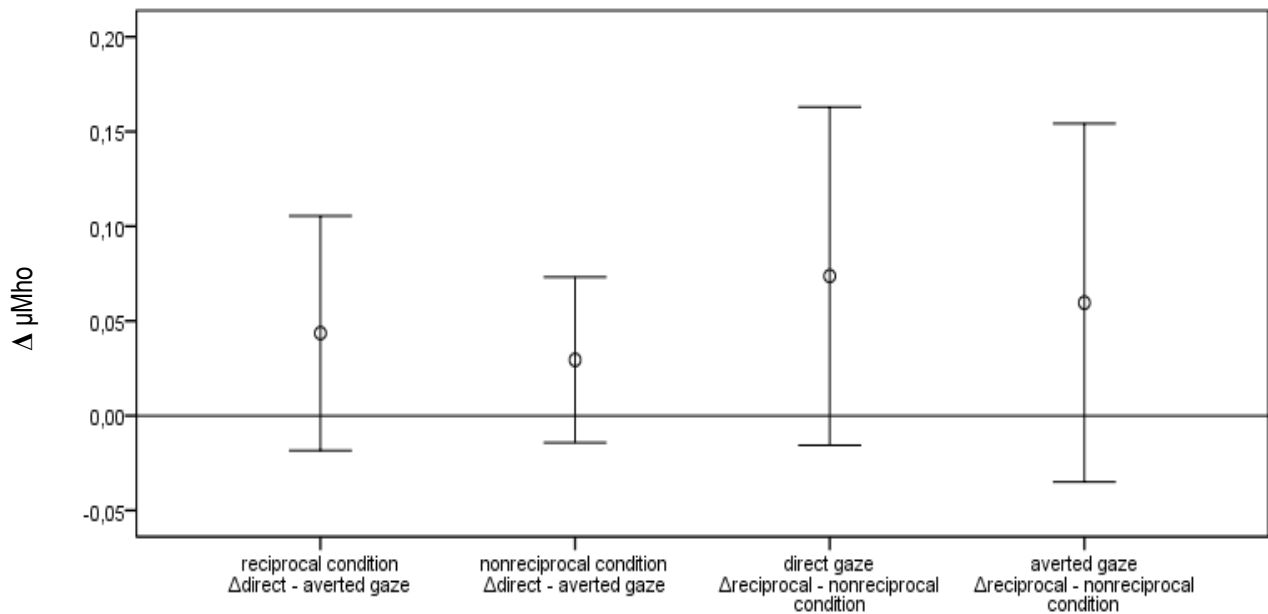
## Skin conductivity results

The mean values of the SCR are presented as a function of gaze direction and reciprocity of the video-link in Table 1. Two statistical tests from the WSR package were conducted on R to analyze the SCR data. The first, `wtrim`, runs multiple comparisons on linear contrasts based on 20% trimmed group means (Wilcox, 2011; 2012). The analysis showed a significant interaction,  $\hat{\psi}=6.84$ ,  $p<.01$ , but no main effects of either Presentation Mode  $\hat{\psi}=1.49$ ,  $p=.22$  or Gaze Direction  $\hat{\psi}=0.02$ ,  $p=.90$ . As recommended by Wilcox (2012) before further analyzing the interaction, another test of multiple comparisons was run to control for a false positive result, better known as a type one error: Although `wtrim` is fit for dealing with nonnormality and heteroscedasticity, unlike previously believed, it has not been created for a within-within situation where the measured groups are not only dependent but the measurements have also been collected from the same group on different occasions (Wilcox, 2012). It is well known that such an analysis, based on group means instead of the means of the matched difference scores of individuals, does not measure whether reactions differ between conditions or not (e.g. Wilcox, 2012). In addition it has recently been noted that `wtrim` has not been shown to react reliably to small sample sizes (Wilcox, 2012).

The SCR data were also tested by using the appropriate R-function `wmcp`. The function, in its default settings, is currently thought fittest for dealing with nonnormality, small samples sizes and heteroscedasticity in a 2x2 within-within setting (Wilcox, 2012). Using a percentile bootstrap sample of matched difference scores, it creates the appropriate linear contrasts. After this, it runs `rmcp`, a modification of ANOVA that performs multiple comparisons among dependent groups. Rom's (1990) method, a version of the Bonferroni correction, is used to control the familywise error rate. The mean difference scores for paired mean magnitudes of SCR can be seen with confidence intervals in Graph 1.

TABLE 1 SCR magnitudes ( $\mu\text{Mho}$ ) for direct and averted gaze as a function of the reciprocity of the video-link.

	Reciprocal			Nonreciprocal		
	<i>M</i>	<i>SD</i>	CI	<i>M</i>	<i>SD</i>	CI
Direct gaze	0.25	0.28	[.11, .34]	0.17	0.18	[.08, .26]
Averted gaze	0.21	0.28	[.06, .35]	0.14	0.20	[.04, .25]



**Graph 1.** Mean difference scores for paired mean magnitudes of SCR

The analysis showed no significant interactions,  $\hat{\psi}=0.05$ , 95% CI= [-0.02, 0.15],  $p= 0.166$ , nor main effects for either presentation mode  $\hat{\psi}=0.10$ , 95% CI= [-0.05, 0.28],  $p=.244$ , or gaze direction,  $\hat{\psi}=-0.01$ , 95% CI= [-0.08, 0.09],  $p=.88$ ).

### Self-report data

A within-within analysis of 20% trimmed group means by `wtrim` and on 20% trimmed mean difference scores by `wmcppb` was performed also on the nonparametric, nonnormal self-reported SAM-data to test the main effects of reciprocity and gaze direction. The analyses were run separately for valence and arousal scores. The mean scores for both can be seen in Table 2.

**Table 2.** Arousal and valence scores (SAM) for reciprocal and nonreciprocal direct gaze as a function of presentation mode. Higher numbers represent greater levels of arousal or more positive valence (Range=0-8)

		Reciprocal			Nonreciprocal		
		<i>M</i>	<i>SD</i>	CI	<i>M</i>	<i>SD</i>	CI
Arousal	Direct gaze	2.06	1.73	[1.19, 2.92]	1.50	1.3	[0.86, 2.14]
	Averted gaze	2.56	1.61	[1.75, 3.36]	1.94	1.8	[1.05, 2.84]
Valence	Direct gaze	4.17	2.18	[3.08, 5.25]	3.89	1.68	[3.06, 4.72]
	Averted gaze	3.61	1.82	[2.71, 4.52]	3.67	1.53	[2.9, 4.43]

With wwtrim, the analysis for self-reported arousal showed a main effect of Presentation Mode ( $\bar{\psi}=4.48, p=.02$ ), but no main effect of Gaze ( $\bar{\psi}=2.31, p=.13$ ) or an interaction ( $\bar{\psi}=0.86, p<.35$ ). The results were found to persist in a wwmcppb analysis based on difference scores: A main effect of Presentation Mode was found for arousal scores ( $\bar{\psi}=-1.08, 95\% \text{ CI}=[-2.08, -0.08], p=.024$ ). There was no main effect of Gaze ( $\bar{\psi}=0.58, 95\% \text{ CI}=[-0.33, 2.33], p=.188$ ) nor a significant interaction ( $\bar{\psi}=-0.25, 95\% \text{ CI}=[-0.75-0.83], p=.56$ ).

For valence, there were no significant results found with wwtrim: no interaction ( $\bar{\psi}=0.70, p<.40$ ) nor a main effect of Presentation Mode ( $\bar{\psi}=0.01, p=.93$ ) or of Gaze ( $\bar{\psi}=1.05, p=.31$ ). The results persisted with wwmcppb, where a further analysis did not show a significant interaction ( $\bar{\psi}=-0.08, 95\% \text{ CI}=[-1.25, 0.75], p=.891$ ), or main effects for either Presentation Mode ( $\bar{\psi}=-0.33, 95\% \text{ CI}=[-1.75-1.08], p=.646$ ), or Gaze ( $\bar{\psi}=-0.83, 95\% \text{ CI}=[-2.17-0.42], p=.192$ ).

Psychophysiological arousal and self-reported arousal for direct gaze were not significantly correlated in the reciprocal or nonreciprocal conditions. The correlation between psychophysiological and self-reported arousal in the reciprocal condition ( $\rho=-.26, p=.30$ ) was not significantly larger than correlation in the nonreciprocal condition ( $\rho=-.20, p=.41$ ),  $z=-0.18, n=17, p=.85$  as tested by Steiger's test B (Steiger, 1980).

The Situational Self-Awareness (SSAS) rating data for direct gaze were normally distributed (Shapiro-Wilk  $>.05$ ) with nondiffering variances (Bartlett's  $K >.05$ ). The mean scores can be seen in Table 2. The data were analyzed separately for each of the three sub-scales of self-awareness (public, private, and surroundings) with paired-samples t-tests on difference scores between the reciprocal and nonreciprocal situations. There was a significant difference in the scores for *public self-awareness* in the reciprocal and nonreciprocal conditions;  $t(16)=2.262, p=.038$ , pooled Cohen's  $d=.405$  and in the scores for *awareness of immediate surroundings* in the reciprocal and nonreciprocal conditions;  $t(16)=-2.491, p=.024$ , pooled Cohen's  $d=.445$  (See Table 3). As predicted, *public awareness* was higher in the presence of the reciprocal link. *Awareness of immediate surroundings* was higher when participants could see the mediated live stimulus without being observed themselves. Both effects were of medium size.

**Table 3.** SSAS-scores for seeing and nonseeing direct gaze for three types of self-awareness (public, private, surroundings). Higher numbers represent greater levels of awareness (Range=0-21).

	Public			Private			Surroundings		
	<i>M</i>	<i>SD</i>	<i>CI</i>	<i>M</i>	<i>SD</i>	<i>CI</i>	<i>M</i>	<i>SD</i>	<i>CI</i>
Reciprocal	8.53	4.65	[6.14,10.92]	10.76	3.35	[9.04,12.48]	11.35	3.66	[9.47, 13.23]
Nonreciprocal	6.94	9.05	[5.40, 8.49]	11.24	2.72	[9.83,12.63]	13.06	4.01	[11.00, 15.12]

The Social Presence data for direct gaze ( $n=18$ ) was normally distributed (Shapiro-Wilk  $>.05$ ) with nondiffering variances (Bartlett's  $K >.05$ ). It was analyzed with a paired-samples t-test comparing the difference scores of the reciprocal ( $m=20.33$ ,  $sd=7.45$ , 95%CI [16.62, 24.04]) and nonreciprocal ( $m=18.611$ ,  $sd=4.692$ , 95%CI [16.27, 20.94]) situation to zero. There was no significant difference between the two situations,  $t(17)=1.152$ ,  $p=.265$ . Also the effect size remained small (nonpooled robust Cohen's  $d=0.173$ ).

# Discussion

## A summary of findings

In this study we used live-feed of facial stimuli to investigate the effect of the mental-state attribution of gaze as seeing on autonomic arousal to direct and averted gaze cues. We also measured self-reported arousal, self-awareness and social presence. Belief in the reciprocity of the link was reported by the participants to have controlled the mental attribution of gaze as seeing. It was not reliably shown, however, that the participants' belief that they were being seen would differently affect skin conductivity responses to direct and averted gaze cues. Despite of this, the reciprocity of the link was shown to have an effect on self-reported arousal, but not valence. Gaze cues did not have an effect neither on autonomic arousal, nor self-reported arousal or valence. The self-reported and autonomic arousal responses to direct gaze were not significantly correlated, and the correlations did not significantly differ between reciprocal and nonreciprocal conditions. The locus of awareness was affected by the reciprocity of the situation, with a reciprocal situation heightening self-reported public self-awareness and a nonreciprocal situation heightening awareness of the environment. The reciprocity of the link did not have an effect on self-reported social presence.

## Autonomic arousal

Autonomic arousal did not differ significantly between responses to facial stimuli presented during a reciprocal and nonreciprocal video-link. Gaze direction had no effect either. As the reciprocity of the link was indeed reported to influence the belief that the model could see the participant, our results do not support the notion that the mental attributions of gaze as seeing or of being seen would heighten psychophysiological arousal.

In light of these results the previously found larger arousal responses to direct than averted gaze do not seem to be explained by the mental attribution of being seen. Moreover, it seems that neither the mental attributions of sentience or being seen, nor recognition of an intention to commence communication (Kampe et al. 2003), explain why at times arousal responses are higher to direct than averted gaze cues. It remains possible, however, that that yet another mental attribution controls whether autonomic arousal responses differ between averted and direct gaze cues.

It is noteworthy, however that there is no direct previous support found for mental attributions to cause the autonomic arousal response to direct gaze. It remains possible that the previously found differentiation between direct and averted gaze cues may have been caused by some unknown low-level factor, which was removed in our experiment by mediating the gazing model through a video-link. Such factors could be tied to olfactory cues, known to both consciously and unconsciously



affect social affective evaluations (Li, Moallem, Paller, & Gottfried, 2007) such as face perception (Walla, 2008) and anticipating the actions of others (Aglioti & Pazzaglia, 2011). The loss of three-dimensionality may also have had an effect.

The nonchanging amount of autonomic arousal between the reciprocal and nonreciprocal conditions implies a constant amount of sympathetic arousal caused by live-streamed facial stimuli. In previous experiments, a change in the loci of awareness has been accompanied with a change in arousal, and alternating loci of awareness have not been found to heighten in respective conditions: These previous experiments have compared live stimuli to pictorial stimuli, with larger arousal responses to live cues (Hietanen et al. 2008, Pönkänen et al. 2011). In the current experiment the stimuli presented in both the reciprocal and the unreciprocal condition were alive. Combined with the heightening of alternating loci of awareness in the reciprocal and unreciprocal conditions, the unchanging amount of arousal suggests that the presence of live facial cues may generate higher amounts of autonomic arousal than other facial cues. Controlling the mental attribution of aliveness in future gaze related arousal research might be needed.

## **Self-awareness and arousal**

As expected, the subjective experience of arousal to gaze cues was found to be higher in the presence of a reciprocal link. This may have been caused by the mental attribution of the gaze as seeing. The occurrence of both heightened public self-awareness and a heightened perception of arousal during the reciprocal situation suggests that there may be a link between them. Self-reported arousal did not correlate with autonomic arousal.

The heightening of both public self-awareness and the perception of the intensity of arousal in the reciprocal situation implies that self-focus affects the way people perceive themselves, and may heighten self-reports of internal states. Indeed, self-focus has previously been found to heighten judgments of felt emotions (Scheier & Carver, 1977). Self-reports on arousal and measurements of psychophysiological arousal were not correlated and the correlations did not differ, implying that public self-awareness does not enable more accurate evaluations of an internal state as has been previously suggested (Gibbons, et al., 1979; Hansen, et al., 1989). Our results suggest that the locus of attention does have an effect on evaluations. Thus it could be induced, that either public self-awareness is linked with intensified judgments of arousal states or heightened awareness of the environment is linked with weakened judgments of arousal states. This could be due to attention allocation towards motivational tendencies crucial for functioning as a social object. These findings support Silvia and Gendolla's (2001) theory, that self-focused attention, at least public self-awareness, does not enable accurate self-knowledge, but rather changes cognitions of the self.

Arousal attribution theories generally postulate that in order for awareness to be allocated somewhere, there needs to be psychophysiological arousal (Harvey, Ickes, & Kidd, 1981). Hansen et al. (1989) have further suggested that whether arousal leads to heightened self-awareness or awareness of the environment is modulated by the accessibility of self-orienting cues. With the levels of autonomic arousal staying constant, the reason for the respective heightening of public self-awareness and awareness of the environment in the reciprocal- and nonreciprocal conditions may well be the mental attribution of the gaze as seeing. It is of interest that direct gaze functions as a stronger self-orienting cue when it is thought to be able to see than when not. Future research directly comparing responses of video-mediated gazing stimuli to live, recorded and pictorial stimuli would be needed to fully understand the importance and effects of immediacy and aliveness for awareness attributions.

As the heightening of public self-awareness was not accompanied by a heightening of arousal, our results suggest that contrarily to previously supposed (e.g. Scheier and Carver, 1977), public self-awareness does not directly cause autonomic arousal. Thus higher arousal responses to direct than averted gaze cannot be caused by heightened public self-awareness due to the mental attribution of being seen, as Hietanen et al. (2008) and Pönkänen et al. (2011) suggested. It is probable that other causes modulate the creation and changes of arousal. Such a cause could be heightened public self-awareness because of high inadequacy attributions.

The heightening of public self-awareness regardless of no change of autonomic arousal or emotional valence questions the basic assumptions underlying the concept of public self-awareness. Buss's (1980) definition of public self-awareness claims that it should be marked by a need to please others in order to alleviate discomfort that rises from a feeling of not being adequate enough to meet social expectations. Linking public self-awareness to direct gaze is based on the idea that the mental attribution of being seen should make people feel uncomfortable. From the point of view of arousal responses these feelings of inadequacy and discomfort do not seem irrelevant, as an uncomfortable feeling has been found to usually accompany a stress reaction associated with the feeling of being looked at (Rimmele & Lobmaier, 2012). Our results imply, consistently with those of Hietanen et al., (2008), that the heightening of public self-awareness does not need to be accompanied by a negatively valenced feeling; i.e., discomfort. Thus it is possible that for the formation of public self-awareness only the attribution of being evaluated is integral, and whether this leads to an expectation of adequacy or inadequacy is irrelevant. Nevertheless it could be that for autonomic arousal responses to heighten, a feeling of inadequacy may be integral.

Feelings of adequacy to meet social standards depend on the relative status of the interactants. Social status is a central element contributing to adequacy attributions thought relevant in the formation of public-self-awareness, and known to play a role in early human information

processing (Foulsham et al., 2010). This is indeed true if the gazer can see the participants better than they can (Argyle et al, 1968). In our experiment, however, the participants were exposed to a situation where they could observe the model without being seen themselves. The inequality of capability to observe one another evokes images of status and power (Barnard-Wills, 2011), and in our experiment this power and the social status coming with it was given to the participants. Furthermore, the relative status between the participants and the model was moderated in ways that heightened the status of the participants, as the feeling of unease that people report to direct gaze has been shown to be moderated by age, sex and known social status (Argyle & Williams, 1969): Both experimenters gave away freely the information that they were students, not professionals, collecting data for their master's thesis. They belonged to the same age group as the participants, aimed at creating a relaxed atmosphere, and the experimenter acting as stimulus was female.

Gained status might have led to a feeling of adequacy, which might have resulted in less unease and less autonomic arousal paired with the mental attribution of being seen. If people believe that they are of equal or greater status than their interactant, one can assume they do not find themselves to be inadequate to meet social standards. Future research should investigate the role of adequacy attributions in moderating arousal responses to direct gaze.

## **Video-mediation**

Video-mediation may have affected autonomic arousal responses and self-reported arousal through altered gaze perception and visual cues as well as different normative scripts. The nondifferentiation of arousal responses to direct and averted gaze may have been caused by altered perception of gaze direction. In a face-to-face contact the discrimination between straight and averted gaze is very accurate, especially for direct gaze (von Grünau, & Anston, 1995; Hugueville, Coelho, & George, 2006; Senju et al., 2005) seen from the front (Gamer & Hecht, 2007). Video-mediated interaction should not change gazing behavior if eye-contact is allowed (O'Malley et al., 1996), but removing eye-contact may either remove or reverse its regulatory function (Short et al., 1976). Different manipulations and sophisticated videoconferencing systems help with this problem. The most simple is to use naïve participants, and simulate eye-contact. When using mediated gazing stimuli people are usually biased to believe they are being engaged in eye-contact: Fixing gaze up to 4.2 cm away from the center of the camera lens at 2.4 m distance has been found to be sufficient to produce the perception of being looked directly in the eyes (Chen, 2002). Even though all but two participants (removed from the analysis) reported a belief that they were seen, it is not certain whether they judged direct gaze to be aimed in the eyes or elsewhere in the face.

Although people have a tendency to think that people are looking at something rather than empty space (Lobmaier, Spanlang, Ruffini, & Slater, 2006) it still remains possible, that the direct

gaze of the model might not have been perceived as locked on the eyes, but for example on the nose or mouth or looking through the participant. Perceiving focus elsewhere in the face is supported by a worry, reported by some participants in the open ended questionnaire, that there was ketchup or a pimple on their face. Chen (2002) also found that in a mediated setting nonfocused gaze in a direct gaze condition is recognized surprisingly well. Hence direct gazes can be perceived as looking "through" the participant in a significant percentage of situations classified as direct gaze. A similar problem of nonfocus in the eyes might have surfaced in our experiment because the model could not really see the participants, but was focusing on the camera lens. Moreover, as the emotional expression of the model was neutral and people have been shown to have a tendency to interpret neutral faces as directed away (Lobmaier, Tiddeman, & Perrett, 2008; Lobmaier & Perrett, 2011) the participants may have been further prejudiced to think that they were not looked in the eye.

Video-links have also been shown to change normative eye gaze patterns (Doherty-Sneddon et al., 1997): People using an eye-contact permitting video-link use direct gaze on average 56% more than participants in a face-to-face condition. Furthermore, a reduced sensitivity to visually conveyed social cues has been reported (Heath & Luff, 1991), suggesting people pay less attention to gaze cues when they are mediated. Thus if people both pay less attention to gaze cues and gaze more, the changed norms allow for more gazing with less sensitivity to it. Reduced sensitivity should lead to reduced reactions, meaning that to induce the same amount of psychophysiological arousal in a video-link situation a higher amount of mutual gaze may be needed than is permissible in a face-to-face setting. It is also possible that if direct gaze does not heighten autonomic arousal in a mediated setting, it is the cause behind the permission people give themselves to gaze more.

Keeping to norms used in face-to-face situations could account for the higher amount of self-reported arousal in the reciprocal condition. These kind of routines and scripts for everyday communication and interaction that humans have are known to be mostly unconscious (Goffman, 1959/1990), and as the participants were naïve to a videoconferencing situation, any new norms might have passed without conscious recognition. Enhanced public self-focus, which we found for the reciprocal condition, is known for prompting self-regulation to adhere with standards (Buss, 1980). If the possibility for interaction and the mental attribution of a seeing gaze are usually linked with higher arousal—as the results for face-to-face gaze perception suggest— (Hietanen et al. 2008, Pönkänen et al. 2011) our participants might have reported more arousal, merely because they thought they should be feeling more aroused.

Changed social norms may have affected autonomic arousal responses through a decrease in pro-social behavior. Previously it has been shown that during mediated interaction low social presence and a lack of social-context cues lead to self-absorption, lack of other-orientation, a lessening of status awareness, depersonalization and to heedlessness of social norms (Kiesler et al.,

1984; Sellen, 1995; Siegel et al., 1986; Sproull & Kiesler, 1986). These effects should have been enhanced in the nonreciprocal condition, which showed heightened awareness of the environment. When awareness of the environment heightens, pro-social motivation has been found to decrease (Ickes et al., 2006). Participants who were not feeling pro-social or were involved in self-absorption should be less interested in commencing interaction, and may thus react differently to direct gaze—a known cue for beginning it.

That we found no difference between arousal responses to direct and averted gaze may thus mark shrunken motivation to act in response to social cues when using a video-link. This would explain some previous findings. Surprisingly the use of a video-link does not enhance ability to collaborate any more than an audio-only link (Sellen, 1995; Andres, 2002) suggesting that the socially significant visual information available is not processed in a similar way as in a face-to-face situation. Furthermore, O'Malley et al., (1996) found seeing only the head while using a video-link to hinder collaboration in comparison with seeing both head and shoulders. This means that the amount of visible bodily cues affects social cognition and motivation.

The amount of visual bodily cues used as stimuli is often not reported in gaze perception studies. Unlike most gaze perception researchers using live stimuli or avatars, but similarly to those using pictures of faces, we presented only the head. In virtual reality settings avatars usually have complete bodies. The technical setting we used (see Picture 2) was basically similar as in previous research at the HIP-laboratory. As can be noted from the size of the LCD shutter, in live situations used by Hietanen et al., (2008) and Pönkänen et al., (2011), parts of the upper torso, including shoulders, have been present. Seeing only the head and losing visual perception of bodily cues, like was the case in our experiment, might come with the cost of less accurate perception of intentionality: Information about posture and movements is known to be combined with visual information from the head and gaze to understand both attention orientation and detect intentional actions (Baron-Cohen, 1995/1999; Jellema Baker, Wicker, & Perrett, 2000; Perret & Emery, 1994; Perret et al., 1989). Attention orientation and perceived intentionality may affect both autonomic arousal and social presence. In addition, as the intensity of emotion is conveyed dissimilarly by different body parts, with the head having been found more informative of the nature and the body of the intensity of emotions (Ekman, 1965, Ekman & Friesen, 1967), the importance for controlling the amount of presented bodily cues is further highlighted. Further research should be conducted on whether the amount of presented visual cues affects both intensity and presence judgments, and whether these changes lead to differing psychophysiological arousal. Perceived intentionality and emotional intensity of the stimuli may well affect general arousal and most importantly for our experiment, arousal to specific social cues, such as direct gaze.

## **Social presence**

Felt social presence did not differ between the reciprocal and nonreciprocal situation. Rather surprisingly it seems that removing the possibility of feedback through either verbal or nonverbal communication did not significantly alter awareness of the presence of another sentient being, nor the perceived ability to connect with the other's mind. The heightening of public self-awareness in the reciprocal situation, however, suggests the participants felt more affected by the internal world of the model when communication would have been possible. From these results it may be deduced that the participants thought that the model judged them differently in different situations.

The reason for the loss of differentiation in self-reported social presence could be that our stimulus presentation did not contain any form of feedback or interactive reciprocity. Perceived and actual quality of interactivity in a mediated environment is known to be lower than in a face-to-face situation (e.g. Sellen, 1995; O'Malley, 1996), but it could be that in our experiment interactivity was so low, that the reciprocal situation could not affect its quality. Martin and Gardner (1979) have previously proposed and given evidence that asocial situations should not produce gaze related arousal. This line of thought implies that the used measure (Salinäs, 2005) did not measure what was intended or that social presence is not an intrinsic quality of a communication medium, as supposed by William and Christie's theoretic construct (1976). These results imply that the more recent, validated and robust Networked minds social presence measure (Biocca, Harms, & Burgoon, 2003; Harms & Biocca, 2004) may be a better choice of measure for future works.

In addition, the perception of intimacy—known to affect social presence—also depends on the range of manners of communication known by the participant to be possible (Short et al., 1976). As the experimenter working as a model was known to be able to walk three steps and open a door to be present face-to-face, video-mediation may not have been considered intimate. A comparison with these face-to-face situations with the experimenter to the video-mediated situations may explain low and nondifferentiating social presence ratings. Not using the same person as a model and as an experimenter would control for this effect in future research.

## **Physical presence**

Physical presence, interpersonal distance and spatial behavior are known to affect arousal responses. Also the proximity of stimuli is known to affect arousal responses. In our experiment, like in other gaze research using mediated stimuli, there is no accurate way of knowing how close the participants felt the stimuli were, and how this affected arousal. Short et al. (1976) report on findings where both the actual physical distances to the interactant as well as the distance to the medium have an effect on such judgement. Mediated interaction also alters interpretations of visual cues, for example Stapley (as cited by Short, et al.1976) has noted that the retinal image of a picture

of a face on a television screen has to be much larger to be subjectively rated at the same proximity as a live face.

Hall (1963) finds the possibility of bodily contact to be crux of all spatial behavior, and removing mutual space removes even the theoretical possibility of touch. Also for Argyle and Dean's (1965) intimacy equilibrium to work, a need for the "absence of physical barriers" has been later postulated (Argyle (1976). The video-link that we used can be seen as a huge physical barrier, firstly presenting the stimuli in the contained box of the television set, and secondly with the model removed into another room. This could explain why live stimuli and those present in virtual reality (where the avatar is perceived to be present in the same room), have been reported to create responses that we did not find in a mediated setting: Realistic face-to-face settings or virtual realities where the results have been obtained contain not only more visual bodily cues but also a sense of mutual space shared by the participant and the gazing model or avatar. When using a video-link a sense of place is not automatically created: Interactants need to knowingly focus on constructing a shared social context, a "sense of place" (Andres, 2002). There are a lot of things that a gazing stimulus mediated by a video-link cannot do that a full bodied person present in the same space has the potential of doing:

*One of the most basic forms of relating in space, one which is deeply im-bedded in man's philogenetic past, is the potential to strike, hold, caress, or groom. In threatening situations among animals, enemies and potential enemies are not permitted within striking distance (Hediger, 1961, pp. 54).*

Heightened arousal may be needed for quick physical responses if an interactant for some reason decides on a form of physical contact. Video-mediated contact can be seen as qualitatively different from face-to-face encounters, as being e.g. "within touching or grasping distance with arms fully extended" (Hall, 1969) to a television set is not the same thing as being as close to a live human. The probability of someone entering personal space might be constantly monitored in social situations, and have an effect on the maintenance of a level of psychophysiological arousal. In a face-to-face situation, the probability of an encounter is deduced from norm governed social behavior, such as direct gaze. When facial stimuli are mediated through a video-link a direct gaze can never be a signal for physical approach. It is of interest that previous research on passively observing hand movements has found that virtual reality hand actions, regardless of whether they are presented on a TV-screen or in 3D-virtual realities, do not map into existing action representations like physically present hand actions do (Perani, Fazio, Borghese, Tettamanti, Ferrari, Decety, & Gilardi, 2001). Our results thus suggest that the importance of proxemics and physical presence in relation with arousal responses to direct gaze should be further researched, for instance by repeating the experiment of Perani et al. (2001) by using gazing stimuli.

## **Methodological issues and limitations of the study**

There are a number of methodological problems that may have affected the results. In addition, a lot of data was discarded, resulting in a decrease of statistical power and reliability.

### **The strength of experimental demands and comparatively higher pre-experimental arousal**

Arousal levels may have been affected by other situational cues. Although SCR should be a good measurement in low-arousal situations (Boucsein 2011; Silverman, Cohen, & Shmavonian, 1959), Patterson (1976) suggests that differentiating effects of arousal in experimental manipulations may be hidden if the preceding anticipation produces a large increase in arousal. High anticipatory arousal followed by a significant drop in arousal may hide skin conductivity responses because of a significant drop in the baseline arousal level. Laboratory experiments were novel for the participants of our experiment, and the strength of experimental demands was not high. It is possible that the long interstimulus intervals created an environment of extremely low stress: Some participants reported feelings of boredom on the open ended questionnaire. The preparations may have created more arousal. Maintaining a constant higher baseline level of arousal might lead to clearer responses to direct gaze cues, because of clearer SCR.

Unlike our low-paced experiment, it seems most previous experiments that have found differentiation between direct and averted gaze cues by SCR responses have contained elements enhancing general arousal or stress throughout stimulus presentation. Physical presence, task difficulty as well as a greater variability of stimuli and the interactivity of the stimulus—found in previous experiments that have reported gaze related changes in autonomic arousal—all work to maintain a consistent level of arousal. For example, involving participants in a difficult task might lead to enhanced autonomic activation even to noninteractive stimuli, because it maintains baseline arousal, not because it allocates cognitive resources elsewhere and thus hinders processing mental attributions, as proposed by Conty et al. (2010). When a sufficient level of autonomic arousal is maintained, a drop in tonic arousal levels cannot hide differences between responses. In future research measuring—or manipulating—another baseline measure of arousal and stress (e.g. heart-rate) between the different presentation modes would clarify the role of general arousal.

In fact a demand for greater baseline arousal is in line with general expectations for SCR enhancement. According to them an effect should be found in situations where "experimental demands are strong enough for the subject to reject active avoidance as an alternative" or they can expect their responses to have an effect (Boucsein, 2011). As the EDA is quick to habituate and the experiment duration was long, it is quite probable that there was no expectation of interactivity from the part of the subjects. In addition, the interstimulus intervals were so long that no form of



energetic activity was necessary to "flee" the situations. Low experimental demands and noninteractivity may well have resulted in low arousal and decreased SCR responses.

The low arousal experimental procedure may also have had other effects. For instance, the stress induced heightening of a feeling of being looked at reported by Rimmel and Lobmaier (2012) might generally have a multiplicative effect on autonomic arousal to gaze cues, with high stress situations heightening the feeling of being looked at and the feeling of being looked at further heightening arousal. Our low-stress experimental procedure paired with the novelty of preparations might have decreased both the feeling of being looked at and measurable responses.

Further research is needed also to clarify how arousal responses to gaze cues differ due to variations of proximity, immediacy, aliveness and status attributions. Other autonomic markers of arousal should be employed, as it is yet unknown, for example, whether the increase in heart-rate to direct gaze in comparison with averted gaze (Kleinke & Pohlen, 1971) disappears in a mediated setting. Such a phenomenon could imply that mediating interaction fundamentally changes motivational tendencies due to its inherent aspects.

### **Obtaining and analyzing the data**

Obtaining and analyzing our data may have created further complications. The largest limitation is posed by the two pseudorandom scripts aimed to randomize the presentation order of direct and averted gaze (Appendix 1). Although random, the used scripts failed in counterbalancing the presentation order of the different gaze directions. The SCR is known to habituate quickly and code the novelty value of environmental stimuli. This means that the amplitude of the responses to the stimuli presented decrease rapidly as a function of time. Both used scripts began with averted gaze, and were identical up to the sixth stimuli, creating a bias towards comparatively larger responses to averted gaze. Furthermore, as autonomic responses of arousal have been suggested to be constantly affected by the first presented gaze direction stimulus (Leavitt & Donovan, 1979), the effect may be additive. It is noteworthy that undeterred by this bias, within each condition, the mean SCR magnitudes for direct gaze were larger than for averted gaze, even though the result did not persist when comparing the mean scores of individual differences. A main or interactive effect of gaze direction on autonomic arousal might have been hidden due to unsuccessful counterbalancing.

Furthermore, a lot of data was discarded because of technical issues, leading to skewed and incomplete datasets, which may have affected the results. Our measurements were made following guidelines on EDA research by the Society for Psychophysiological Research (Fowles et al., 1981). Similar future problems may be evaded by following new standards for performing EDA research, which the SPR Committee on Electrodermal Measures has announced they will publish in 2012 in *Psychophysiology* (Boucsein, 2012). The repetition of the experiment in accordance with the new

standards would be advisable. There have been numerous advancements in understanding the EDA and what should be taken into account, with some of them already in widespread use.

Over a third of the data collected was let go because of an excess of disturbances in the SCR signals. Our experiment—as well as future experiments with similar settings—would have especially profited from technical solutions aimed to minimize the problems created by artifacts, overlapping SCR responses and separating tonic SCL from SCR. Our recordings were done with only one channel, similarly to traditional skin conductance measurements, reflecting both slow tonic and fast phasic changes of the EDA (i.e., SCL and SCR). Manual separation of discreet SCRs from each other and from tonic SCL changes was required. This technique of data collection leads to disowning data with large tonic changes or overlapping SCRs, both characteristic to our experiment: Our experimental design was especially apt to create overlapping SCR reactions because of the nonchanging task requiring overt verbal responses directly after each stimulus was presented. Paired with the physical presence of the experimenter taking care of the devices, anticipating these verbal responses could have affected electrodermal conductivity. The use of semi-automatic interactive procedures together with automatic procedures in order to locate critical artifacts and at the same time minimizing overlaps and distortions by preceding SCR's and the changes in SCL is recommended by Boucsein (2011). These methods include the use of a difference function (see Naqvi & Bechara, 2006) or using a high-pass software filter and more than one channel (Figner & Murphy, 2011). The development of methods for nonnegative convolution of EDA-data also shows excellent possibilities for decomposing overlapping responses in a reliable manner (Benedek & Kaernbach, 2010). For example, treating the data with a low-pass filter or a smoothing function would remove electromagnetic disturbances, e.g. from equipment and fluorescent lights (Figner & Murphy, 2011), and other electrical equipment, also abundant in our experiment.

Using these methods in future research might permit the use of complete data sets—and classical statistical methods. The nonnormality of our SCR dataset is not uncommon: SCR magnitude has been found to be a generally skewed measure (Fowles et al., 1981; Venables & Christie, 1980). Recent research indicates the usefulness of standardizing SCR data within each participant to reduce variance due to physiological causes, like the thickness of the corneum (Boucsein, 2011; Dawson et al., 2007). Furthermore, the introduction of the SCR surface measure,  $s_2$  (Figner & Murphy, 2011; Sequiera, 2009) has been found to help obtain datasets that are easier to analyze.

Controlling for variables known to have an effect on skin conductivity was also incomplete. As the sensitivity to habituation and reactivity to stimulus intensity of SCR's from distal phalanges in comparison with medial phalanges has been reported to be greater, and SCR amplitudes from the distal phalanges have been found to be about 3.5 times larger than those from medial phalanges

(Scerbo, Freedman, Raine, Dawson, & Venables, 1992), the placement of electrodes should be reconsidered in future research. Also, because temperature and humidity can influence skin conductance through the hydration of the corneum (Boucsein, 2011), either controlling both room temperature and humidity to remain constant or recording their measures for covariance analysis during the collection of EDA would be advisable. As the EDA is a marker susceptible to the diurnal changes in emotional reactivity and processing (Hot, Leconte, & Sequiera, 2004; Sequiera, 2009), collecting the data only in the afternoons or morning would make future recordings more reliable.

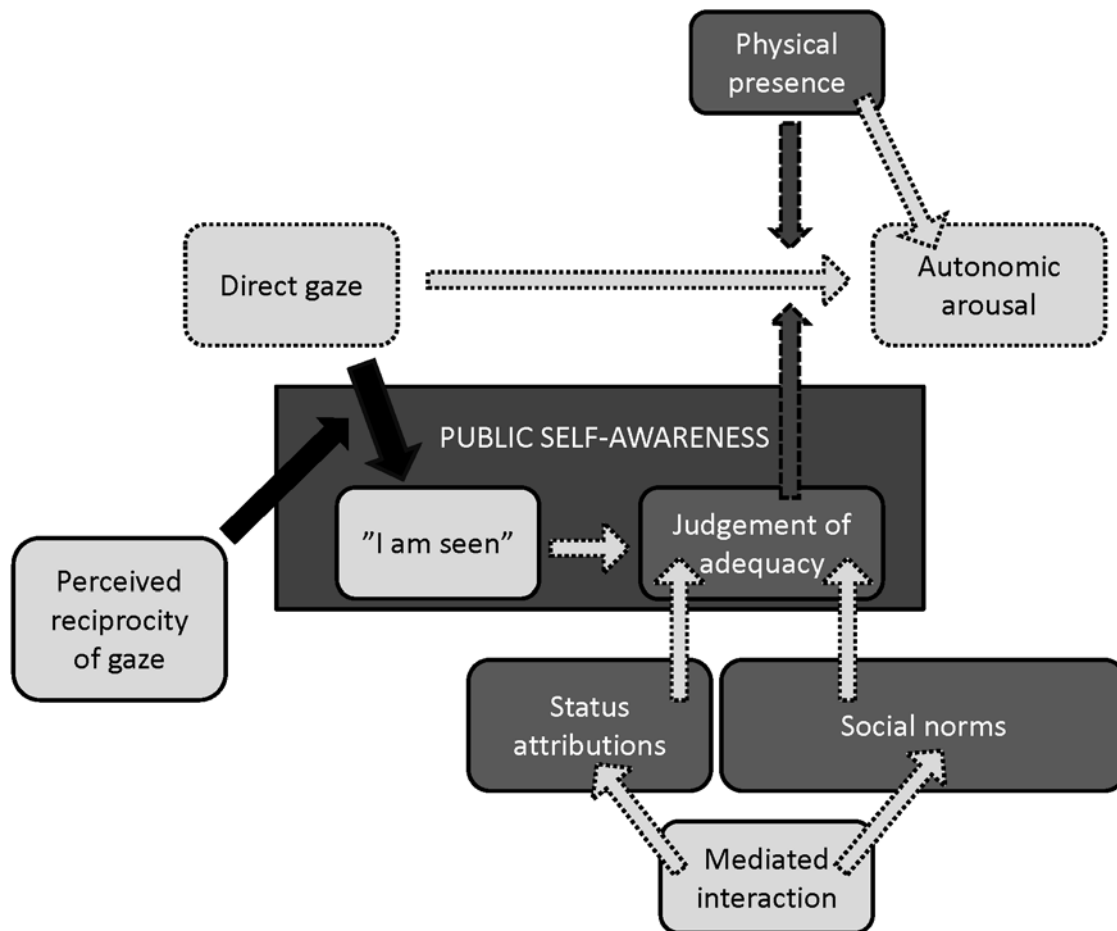
The gazing behavior of the model may have affected the results. It was not commonplace, as head nods, breathing and eye blinks were kept at such a minimum as to be nonexistent. Increasing the behavioral realism of gazing stimuli has been shown to directly affect intimacy behavior, with head nods, slight changes in breathing patterns and eye-blinks affecting especially women (Bailenson, Blascovich, Beall, & Loomis, 2001). In addition, realistic gazing behavior has been shown to enhance perceived interactivity (Bente, Eschenburg, & Krämer, 2007; Garau et al., 2003; Vinayagamoorthy, Garau, Steed, & Slater, 2004) and social presence (Bente & Eschenburg, 2007). Both felt social presence and interactivity affect intimacy judgments, and perceived intimacy is thought to affect autonomic arousal (Argyle, 1976; Argyle & Dean, 1965).

The results might also have been affected by the facial features and neutral emotional facial expression of the experimenter acting as a model, not to mention the sex and personalities of both the participants and the model. Previous studies have shown that differing reactions to direct and averted gaze are modulated by individual attributes of the gazing model (Conway, Jones, DeBruine, & Little, 2008, Kampe et al., 2001, O'Doherty et al., 2003, Pönkänen et al., 2011) and participants (Conway, Jones, DeBruine, Little, Hay et al. 2008; Helminen et al., 2011), and the sex of both (Conway, Jones, DeBruine, & Little, 2008; Donovan & Leavitt, 1981; Mason, Tatkov & Macrae, 2005). We used just one model, who additionally acted as an experimenter preparing the participants for measurements. This may have heightened individual effects. Furthermore, impression formation, crucial for attributions of status and intimacy, is affected by physical distance, especially close physical contact early during interaction (Patterson & Secherest, 1970). In future research, using a model not working as an experimenter would control some of the effects due to personality and individual attributions, as would using the sex of both the model and the participants as a between subjects variables.

## **Conclusions**

The mental attribution of gaze as seeing did not affect psychophysiological arousal responses so that they would have differentiated between direct and averted gaze. Nevertheless, the mental attribution of being seen did heighten self-reported arousal and public self-awareness. Public self-

awareness, however, was not found to correlate with arousal responses. Thus neither the mental attribution of gaze as seeing nor public self-awareness seems to cause the differentiating autonomic arousal response previously found between direct and averted gaze. Because of methodological issues, the results obtained should be confirmed by replications and future studies.



**Figure 2:** A theoretic framework for the way being seen, public self-awareness, and physical proximity may moderate autonomic arousal to direct gaze. Our results are depicted with black arrows, previous research with light gray arrows and effects suggested for future research with dark gray arrows. The factors present also in Figure 1 are within light gray boxes.

The theoretic framework we based our hypothesis on (as visualized in Figure 1) is updated with the aforementioned results in Figure 2. In light of previous experiments it seems that direct gaze at times leads to autonomic arousal (light gray arrow). Considering our findings it seems that the perceived reciprocity of gaze indeed mediates whether direct gaze leads to heightened public self-awareness (black arrows). The possible factors moderating the autonomic arousal response,

however, have been changed. In accordance with self-awareness theories, being seen is thought of as a factor of the state of being publicly self-aware (dark gray box). The use of mediated interaction is acknowledged to affect the other factor of public self-awareness, adequacy attributions, through its widely recognized effects on status attributions and social norms (light gray arrows). Judgments of adequacy are proposed to moderate autonomic arousal responses to direct gaze together with physical presence (dark gray arrows), prompting further research.

To conclude, we suggest that the mental attribution of being seen does not have an effect on arousal, but it makes people focus on themselves and changes the way they perceive their arousal state. We suggest that instead social cues and physical presence may moderate autonomic arousal responses to direct gaze cues and that both should be further researched. Furthermore, our experiment highlights the importance of conducting further research on gaze induced autonomic arousal by comparing stimuli in face-to-face, video-mediated, and virtual reality-settings to help understand how and why gaze functions in social cognition.

Removing physical presence may change social cognition profoundly. Gaze is used as a cue for commencing interaction, and so psychophysiological arousal due to direct gaze might take place only in situations where the participants find the commencement of interaction firstly possible and secondly probable. Nevertheless, the mental attributions of aliveness and immediacy, associated with video-links, could be behind the found heightened awareness of surroundings in the nonreciprocal condition. In future experiments, the effects of perceived interactivity and possibility of physical contact should be controlled and measured.

Mediated social cues may generally elicit less arousal and hence have smaller motivational effects. Nonheightened arousal to social cues may be a key element contributing to effects specific for mediated interaction: When social cues lessen, people tend to be more self-absorbed than other-oriented, their social orientation of status lessens, and they behave in a way that confirms less to social norms (Kiesler et al., 1984; Siegel et al., 1986; Sproull & Kiesler, 1986). If the lack of arousal to social cues is found to persist in video-situations but not in 3D-virtual reality settings, the use of the latter for counseling and teaching purposes would be advisable. Our results highlight the importance of face-to-face encounters in modern life.

Many central theories on social gaze, such as those of social anxiety, rely on the assumption that the mental attribution of being seen is behind arousal responses—and arousal induced emotional attribution—due to direct gaze. According to our results, however, it seems that instead of linking gaze related arousal to the mental attribution of being seen, other aspects and mental attributions affecting social cognition should be taken under scrutiny. This study does not rule out the possibility that autonomic arousal responses to direct face-to-face gaze may be stimulus driven instead of based on mental attributions, although the exact type of stimulus has yet to be confirmed. In

addition with drawing attention to the basic variables of social gaze, like aliveness and interactivity, our results highlight the importance of understanding, researching and taking into account the multifacial theoretical constructs, like public self-awareness and presence, when studying the effects of social gaze.

# Bibliography

- Adams, R.B., Franklin, R. G., Nelson, A. J., & Stevenson, M. T. (2011). Compound social cues in human face processing. In R. B. Adams, N. Ambady, K. Nakayama, & S. Shimojo (Eds.). *The Science of Social Vision*, (pp.90–107). Oxford: Oxford University Press.
- Adams, R.B., Jr., Rule, N., Franklin, R.G., Jr., Wang, E., Stevenson, M.T., Yoshikawa, S., Nomura, M., Sato, W., Kveraga, K., & Ambady, N. (2010). Cross-cultural reading the mind in the eyes: An fMRI investigation. *Journal of Cognitive Neuroscience*, 22, 97–108.
- Aglioti, S. M. & Pazzaglia M. (2011). Sounds and scents in (social) action. *Trends in Cognitive Sciences*, 15: 47-55
- Alden, L. E., Teschuk, M., & Tee, K. (1992). Public self-awareness and withdrawal from social interactions. *Cognitive Therapy and Research*, 3, 249–267
- Andres, H. P. (2002). A comparison of face-to-face and virtual software development teams. *Team Performance Management*, 8, 39–48.
- Argyle, M. (1969). *Social interaction*. London: Tavistock Press.
- Argyle, M., & Cook, M. (1976). *Gaze and mutual gaze*. Cambridge: Cambridge University Press.
- Argyle, M., & Dean, J. (1965). Eye contact, distance, and affiliation. *Sociometry*, 28, 289–304.
- Argyle, M., & Williams, M. (1969). Observer of observed? A reversible perspective in person perception. *Sociometry*, 32, 396–412.
- Argyle, M., Lalljee, M., & Cook, M. (1968). The effects of visibility on interaction in a dyad. *Human Relations*, 21, 13–17.
- Bailenson, J. N., Blascovich, J., Beall, A. C., & Loomis, J. M. (2001). Equilibrium theory revisited: Mutual gaze and personal space in virtual environments. *Presence: Teleoperators and Virtual Environments*, 10, 583–598.
- Bailey, R.C., Chorosovic, P., White, D., & White, H. (1981). Physiological arousal and perceptions of a member of the opposite sex. *Journal of Sociological Psychology*, 115, 271–276.
- Baldassare, M., & Felder, S. (1975). Cultural variations in personal space: Theory, methods, and evidence. *Ethos*, 3, 481–503.
- Barnard-Wills, D. (2011). UK news media discourses of surveillance. *The Sociological Quarterly*, 52, 548–567.
- Baron-Cohen, S. (1999). *Mindblindness: An essay on autism and theory of mind* (6th pr. ed.). Cambridge, Mass: MIT Press.
- Bechara, A., Tranel, D., Damasio, H., & Damasio, A. R. (1996). Failure to respond autonomically to anticipated future outcomes following damage to prefrontal cortex. *Cereb Cortex*, 6, 215–225.
- Benedek, M., & Kaernbach, C. (2010). Decomposition of skin conductance data by means of nonnegative deconvolution. *Psychophysiology*, 47, 647–658
- Bente, G., Eschenburg, F., & Krämer, N. (2007). Virtual gaze. A pilot study on the effects of computer simulated gaze in avatar-based conversations. In Randall Schumaker (Ed.) *Lecture Notes in Computer Science vol. 4563, Virtual Reality* (pp. 185-194) . doi:10.1007/978-3-540-73335-5\_21

- Bini, G., Hagebarth, K.-E., Hynninen, P., & Wallin, B. G. (1980). Thermoregulatory and rhythm-generating mechanisms governing the sudomotor and vasoconstrictor outflow in human cutaneous nerves. *Journal of Physiology*, *306*, 537–552.
- Biocca, F., Harms, C., & Burgoon, J. K. (2003). Toward a more robust theory and measure of social presence: Review and suggested criteria. *Presence: Teleoperators and Virtual Environments*, *12*, 456–480. doi: 10.1162/105474603322761270
- Biocca, F., Harms, C., & Gregg, J. (2001). The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity. Paper presented at the International Workshop on Presence, Philadelphia, PA. Retrieved from: <http://astro.temple.edu/~lombard/P2001/Biocca2.pdf>
- Bischof-Köhler, D. (1991). The development of empathy in infants. In M.E. Lamb, & H. Keller (Eds.), *Infant Development. Perspectives from German speaking countries* (245–273). Hillsdale: Lawrence Erlbaum Associates
- Blair, R. C., & Higgins, J. J. (1985). A comparison of the power of the paired samples rank transform statistic to that of Wilcoxon's signed ranks statistic. *Journal of Educational and Behavioral Statistics*, *10*, 368–383.
- Boucsein, 2012. [Personal webpage]  
<http://www2.uniwuppertal.de/FB3/psychologie/physio/eda.htm>. Retrieved 12.2.2012
- Boucsein, W. (2011). *Electrodermal activity*. New York: Plenum University Press.
- Bradley, J. V. (1978). Robustness? *British Journal of Mathematical and Statistical Psychology*, *31*, 144–152.
- Bradley, J. V. (1980). Nonrobustness in Z, t, and F tests at large sample sizes. *Bulletin of the Psychonomic Society*, *16*, 333–336.
- Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavioral Therapy and Experimental Psychiatry*, *25*, 49–59.
- Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion*, *1*, 276–298.
- Burgoon, J. K., Buller, D. B., & Woodall, W. G. (1989). *Nonverbal communication: The unspoken dialogue*. New York: Harper, & Row.
- Buss, A. H. (1980). *Self-consciousness and social anxiety*. San Francisco: Freeman.
- Calder, A. J., Lawrence, A. D., Keane, J., Scott, S. K., Owen, A. I., Christoffels, I., & Young, A.W. (2002). Reading the mind from eye gaze. *Neuropsychologia*, *40*, 1129–1138.
- Caron, A. J., Kiel, E. J., Dayton, M., & Butler, S. C. (2002). Comprehension of the referential intent of looking and pointing between 12 and 15 months. *Journal of Cognition, & Development*, *3*, 445–464.
- Carver, C.S., & Scheier, M.F. (1981). *Attention and self regulation: A control-theory approach to human behavior*. New York: Springer-Verlag.
- Chen, M. (2002). Leveraging the asymmetric sensitivity of eye contact for videoconference. In D. Wixon, (Ed.) *Conference on Human Factors in Computing Systems – Proceedings, vol 4, CHI'02 Human Factors in Computing Systems* (pp. 49–56). doi: 10.1145/503376.503386
- Conover, W. J., & Iman, R. L. (1981). Rank transformations as a bridge between parametric and nonparametric statistics. *American Statistician*, *35*, 124–129.



- Conty L., Tijus C., Hugueville L., Coelho E., & George N. (2006). Searching for asymmetries in the detection of gaze contact versus averted gaze under different head views: A behavioural study. *Spatial Vision, 19*, 529–545
- Conty, L., Russo, M., Loehr, V., Hugueville, L., Barbu, S., & Huguet, P., et al. (2010). The mere perception of eye contact increases arousal during a word-spelling task. *Social Neuroscience, 5*, 171–186.
- Conway, C. A, Jones, B. C, DeBruine, L. M., & Little, A. C., (2008). Evidence for adaptive design in human gaze preference. *Proceedings of the Royal Society of London, Series B, 275*, 63 –69
- Conway, C. A, Jones, B. C, DeBruine L. M., Little A. C., Hay J., Perrett D. I., & Feinberg D. R. (2008). Integrating physical and social cues when forming face preferences: Differences among low and high anxiety individuals. *Social Neuroscience, 3*, 89 –95
- Cook, E. W. III, Hawk, L. W., Davis, T. L., & Stevenson, V. E. (1991). Affective individual differences and startle reflex modulation. *Journal of Abnormal Psychology, 100*, 5–13.
- Critchley, H. D. (2009). Psychophysiology of neural, cognitive and affective integration: fMRI and autonomic indicants. *International Journal of Psychophysiology, 73*, 88–94.
- Critchley, H.D. (2002). Electrodermal responses: What happens in the brain. *Neuroscientist, 8*, 132–42.
- Critchley, H.D. (2005). Neural mechanisms of autonomic, affective, and cognitive integration. *The Journal of Comparative Neurology, 493*, 154–166
- Damasio, A., (2000). *The feeling of what happens: Body, emotion and the making of consciousness* (2<sup>nd</sup> ed.). London (U.K.). Vintage
- Dawson, M. E., Schell, A. M., & Filion, D. L. (2007). The electrodermal system. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of psychophysiology* (3<sup>rd</sup> ed., pp. 159–181). Cambridge, UK: Cambridge University Press.
- de Greef, H.P., & IJsselsteijn, W.A. (2000). Social Presence in the PhotoShare Tele-Application. *Proceedings of PRESENCE 2000, Delft, The Netherlands, 27–28*. Retrieved from <http://ispr.info/presence-conferences/previous-conferences/presence-2000/>
- Doherty-Sneddon, G., Anderson, A., O'Malley, C., Langton, S., Garrod, S., & Bruce, V. (1997). Face-to-face and video-mediated communication: A comparison of dialogue structure and task performance. *Journal of Experimental Psychology: Applied, 3*, 105–125.
- Donovan, W. L., & Leavitt, L.A. (1980). Physiological correlates of direct and averted gaze. *Biological Psychology, 10*, 189–201. Abstract retrieved from [http://www.ncbi.nlm.nih.gov/pubmed/doi:10.1016/0301-0511\(80\)90014-9](http://www.ncbi.nlm.nih.gov/pubmed/doi:10.1016/0301-0511(80)90014-9)
- Duffy, E. (1951). The concept of energy mobilization. *Psychological Review, 58*, 30-40.
- Ekman, P. (1965). Differential communication of affect by head and body cues. *Journal of Personality and Social Psychology, 2*, 725–735.
- Ekman, P., & Friesen, W. V. (1967). Head and body cues in the judgement of emotion: A reformulation. *Perceptual and Motor Skills, 24*, 711–724.
- Emery, N. J. (2000). The eyes have it: The neuroethology, evolution and function of social gaze. *Neuroscience, & Biobehavioral Reviews, 24*, 581–604.
- Erceg-Hurn, D. M., & Mirosevich, V. M. (2008). Modern robust statistical methods: An easy way to maximize the accuracy and power of your research. *American Psychologist, 63*, 591–601.

- Fahoome, G., & Sawilowsky, S. S. (2000). Review of twenty nonparametric statistics and their large sample approximations. Paper presented at the annual meeting of the American Education Research Association. Retrieved from <http://www.eric.ed.gov/PDFS/ED441031.pdf>
- Farroni, T., Csibra, G., Simion, F., & Johnson, M. H., (2002). Eye contact detection in humans from birth. *Proceedings of the National Academy of Sciences of the United States of America*, *99*, 9602–9605.
- Fejfar, M. C., & Hoyle, R. H. (2000). Effect of private self-awareness on negative affect and self-referent attribution: A quantitative review. *Personality and Social Psychology Review*, *4*, 132–142.
- Fenigstein, A., Scheier, M. F., & Buss, A.H. (1975). Public and private self-consciousness: Assessment and theory. *Journal of Consulting and Clinical Psychology*, *43*, 522–527.
- Figner, B., & Murphy, R. O. (2011). Using skin conductance in judgment and decision making research. In M. Schulte-Mecklenbeck, A. Kuehberger, & R. Ranyard (Eds.), *A handbook of process tracing methods for decision research* (pp. 163–184). New York, NY: Psychology Press
- Foulsham, T., Cheng, J. T., Tracy, J. L., Henrich, J., & Kingstone, A. (2010). Gaze allocation in a dynamic situation: Effects of social status and speaking. *Cognition*, *117*, 319–331.
- Fowles, D. C. (1986). The eccrine system and electrodermal activity. In MGH Coles, E Donchin, SW Porges (Eds.), *Psychophysiology*, (pp. 51–96). Guilford Press, New York
- Fowles, D. C. (1980). The three arousal model: Implications of Gray's two-factor learning theory for heart rate, electrodermal activity, and psychopathy. *Psychophysiology*, *17*, 87–104.
- Fowles, D.C., Christie, M.J., Edelberg, R., Grings W.W., Lykken D.T., & Venables P.H. (1981). Publication recommendations for electrodermal measurements. *Psychophysiology*, *18*, 232.
- Gale, A., Lucas, B., Nissim, R., Harpham, B., (1972). Some EEG correlates of face-to-face contact. *British Journal of Social and Clinical Psychology*, *11*, 326–332.
- Gale, A., Spratt, G., Chapman, A.J., Smallbone, A., (1975). EEG correlates of eye contact and interpersonal distance. *Biological Psychology*, *3*, 237–245.
- Gamer, M., & Hecht, H. (2007). Are you looking at me? Measuring the cone of gaze. *Journal of Experimental Psychology, Human Perception, & Performance*, *33*, 705–715.
- Garau, M., Slater, M., Vinayagamoorthy, V., Brogny, A., Steed, A., & Sasse, M. A. (2003). The impact of avatar realism and eye gaze control on perceived quality of communication in a shared immersive virtual environment. In Cocton, G. (Ed.) *Proceedings of CHI'03. Human factors in computing systems* (pp. 529-536). doi: 10.1145/642611.642703
- Gibbons, F. X., Carver, C. S., Scheier, M. F., & Hormuth, S. (1979). Self-focused attention and the placebo effect: Fooling some of the people some of the time. *Journal of Experimental Social Psychology*, *15*, 263–274
- Gibbons, F. X. (1990). Self-attention and behavior: A review and theoretical update. In M. P. Zanna (Ed.), *Advances in Experimental Social Psychology*, *23*, (pp. 249–303), New York: Academic Press.
- Goffman, E. (1959/1990). *The presentation of self in everyday life*. University of Edinburgh Social Sciences Research Centre.
- Gomez, J. C. (1994). Mutual awareness in primate communication: A Gricean approach. In S.T. Parker, R.W. Mitchell, and M.L. Boccia (Eds), *Self-awareness in animals and humans: Developmental perspectives* (pp. 61–80). New York: Cambridge University Press.

- Govern, J. M., & Marsch, L. A. (1997). Inducing positive mood without demand characteristics. *Psychological Reports, 81*, 1027–1034.
- Govern, J. M., & Marsch, L. A. (2001). Development and validation of the Situational Self-Awareness Scale. *Consciousness and Cognition, 10*, 366–378.
- Graham, F. K., & Clifton, R. K. (1966). Heart-rate change as a component of the orienting response. *Psychological Bulletin, 65*, 305–320.
- Gray, J., & Mc Naughton, N. (2007). *The neuropsychology of anxiety: An enquiry into the functions of the septo-hippocampal system*, (2nd ed). Oxford : Oxford University Press, 2007.
- Grayson, D. M., & Monk (2003). Are you looking at me? Eye contact and desktop video conferencing. *ACM Transactions on Computer-Human Interaction, 10*, 221–243.
- Grissom, R. J. (2000). Heterogeneity of variance in clinical data. *Journal of Consulting and Clinical Psychology, 68*, 155–165.
- Grünau, M., von, & Anston, C. (1995). The detection of gaze direction: A stare-in-the-crowd effect. *Perception, 24*, 1297–1313.
- Hains, & Muir (1996). Infant sensitivity to adult eye direction. *Child Development, 67*, 1940–1950
- Hall, E. T. (1963). A system for the notation of proxemic behaviour. *American Anthropologist, 65*, 1003–1026.
- Hall, E. T. (1969). *The hidden dimension*. Garden City (NY). Doubleday.
- Hansen, R. D., Hansen, C. H., & Crano, W. D. (1989). Sympathetic arousal and self-attention: The accessibility of interoceptive and exteroceptive arousal cues. *Journal of Experimental Social Psychology, 25*, 437–449.
- Harms, C., & Biocca, F. (2004). Internal consistency and reliability of the networked minds social presence measure. In M. Alcaniz, & B. Rey (Eds.), *Seventh Annual International Workshop: Presence 2004* (pp.246-251). Retrieved from <http://ispr.info/presence-conferences/previous-conferences/presence-2004/>
- Harvey, J., Ickes, W., & Kidd, R. (1981) *New directions in attribution research. 3*. Hillsdale, N.J. : Lawrence Erlbaum Associates
- Harwell, M. R., Rubinstein, E. N., Hayes, W. S., & Olds, C. C. (1992). Summarizing Monte Carlo results in methodological research: The one and two-factor fixed effects ANOVA cases. *Journal of Educational Statistics, 17*, 315–339.
- Heath, C., & Luff, P (1991). Disembodied conduct: Communication through video in a multi-media office environment. In Robertson, S., Olson, G., & Olson, J. (Eds.) *Proceedings of the SIGCHI conference, (CHI '91), Human Factors in Computing Systems: Reaching through Technology*, (pp.99-103). doi:10.1145/108844.108860
- Heeter, C. (1992). Being there: The subjective experience of presence. *Presence, 1*, 262–271.
- Helminen, T. M., Kaasinen, S. M., & Hietanen, J. K. (2011). Eye contact and arousal: The effects of stimulus duration. *Biological Psychology, 88*, 124–130.
- Hietanen, J. K., Leppänen, J. M., Peltola M. J., Linna-aho, K., & Ruuhiala, H.J. (2008). Seeing direct and averted gaze activates the approach-avoidance motivational brain systems. *Neuropsychologia, 46*, 2423–2430.

- Hot, P., Leconte, P., & Sequiera, H. (2005). Diurnal autonomic variations and emotional reactivity. *Biological Psychology*, *69*, 261–270.
- Ickes, W., Holloway, R., Stinson, L. L., & Hoodenpyle, T. G. (2006). Self-monitoring in social interaction: The centrality of self-affect. *Journal of Personality*, *74*, 659–684.
- Jellema T., Baker C. I., Wicker B., & Perrett DI. (2000). Neural representation for the perception of intentionality of actions. *Brain and Cognition*, *44*, 280–302.
- Kampe, K.K., Frith, C.D., Dolan, R.J., & Frith, U. (2001). Reward value of attractiveness and gaze. *Nature*, *413*, 589.
- Kampe, K.K.W., Frith, C.D., & Frith, U. (2003). "Hey John": Signals conveying communicative intention toward the self activate brain regions associated with "mentalizing", regardless of modality. *Journal of Neuroscience*, *23*, 5258–5263.
- Kelly, E. W. (1978). Effects of counselor's eye contact on student-client perceptions. *Perceptual and Motor Skills*, *46*, 627–632. Abstract retrieved from <http://www.proquest.com>
- Kendon, A. (1967). Some functions of gaze-direction in social interaction. *Acta Psychologica*, *26*, 22–63.
- Keppel, G., & Wickens, T.D. (2004). *Design and analysis: A researcher's handbook* (4th ed). Upper Saddle River, NJ : Pearson/Prentice Hall
- Kiesler, S., Siegel, J., & McGuire, T. W. (1984). Social psychological aspects of computer-mediated communication. *American Psychologist*, *39*, 1123–1134.
- Kimble, C.E., Forte, R.A., & Yoshikawa, J.C. (1981). Nonverbal concomitants of enacted emotional intensity and positivity: Visual and vocal behavior. *Journal of Personality*, *49*, 271–283.
- Kleinke, C. L. (1986). Gaze and eye contact: A research review. *Psychological Bulletin*, *100*, 78–100.
- Kleinke, C. L., Bustos, A. A., Meeker, F. B., & Staneski, R. A. (1973). Effects of self-attributed and other-attributed gaze in interpersonal evaluations between males and females. *Journal of Experimental Social Psychology*, *9*, 154–163.
- Kleinke, C. L., & Pohlen, P. D. (1971). Affective and emotional responses as a function of other person's gaze and cooperativeness in a two person game. *Journal of Personality and Social Psychology*, *17*, 303–313.
- Kleinke, C. L., Staneski, R. A., & Berger, D. E. (1975). Evaluation of an interviewer as a function of interviewer gaze, reinforcement of subject gaze, and interviewer attractiveness. *Journal of Personality and Social Psychology*, *31*, 115–122.
- Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*, 261–273
- Langton, S.R.H. (2000). The mutual influence of gaze and head orientation in the analysis of social attention direction. *Quarterly Journal of Experimental Psychology*, *53*, 825–845.
- Leavitt, L.A., & Donovan, W.L. (1979). Perceived infant temperament, locus of control, and maternal physiological response to infant gaze. *Journal of Research in Personality*, *13*, 267–278
- Leech, N. L., & Onwuegbuzie, A. J. (2002). A call for greater use of nonparametric statistics. Paper presented at the Annual Meeting of the Mid-South Educational Research Association. Paper retrieved from <http://www.eric.ed.gov/PDFS/ED471346.pdf>

- Lewis, M. (2001). Origins of the self-conscious child. In W.R. Crozier & L.E. Alden (Eds.), *International Handbook of Social Anxiety: Concepts, Research and Interventions relating to the Self and Shyness* (pp.101–118). New York: JohnWiley, & Sons.
- Li, W., Moallem, I., Paller, K.A., & Gottfried, J.A. (2007). Subliminal smells can guide social preferences. *Psychological Science*, 18, 1044-1049
- Lindsley, D. B., Knowles, & Magoun, 1950 (1950). Behavioral and EEG changes following chronic brain stem lesions in the cat. *Electroencephalography and Clinical Neurophysiology*, 2, 483–498.
- Lix, L.M., Keselman, J.C., & Keselman, H.J. (1996). Consequences of assumption violations revisited: A quantitative review of alternatives to the one-way analysis of variance F test. *Review of Educational Research*, 66, 579–619.
- Llobera, J., Spanlang, B., Ruffini, G., & Slater, M. (2010). Proxemics with multiple dynamic characters in an immersive virtual environment. *ACM Transactions on Applied Perception*, 8, 1. doi:10.1145/1857893.1857896
- Lobmaier, J. S., & Perrett, D. I. (2011). The world smiles at me: Self-referential positivity bias when interpreting direction of attention. *Cognition and Emotion*, 25, 334–341.
- Lobmaier, J. S., Tiddeman, B.P., & Perrett, D. I. (2008). Emotional expression modulates perceived gaze direction. *International Journal of Psychology*, 43, 38–38.
- Lobmaier, J.S., Fischer, M., & Schwaninger, A. (2006). Objects capture perceived gaze direction. *Experimental Psychology*, 53, 117–122.
- Macefield, V. G., & Wallin, B. G. (1996). The discharge behaviour of single sympathetic neurones supplying human sweat glands. *Journal of the Autonomic Nervous System*, 61, 277–286.
- Martin, W.W., Gardner, S.N., (1979). The relative effects of eye-gaze and smiling on arousal in asocial situations. *The Journal of Psychology*, 102, 253–259.
- Mason, M. F., Tatkov, E., P., & Macrae, C., N. (2005). The look of love: Gaze shifts and person perception. *Psychological Science*, 16, 236–239.
- McBride, G., King, M.G. & James, J.W. (1965). Social proximity effects on galvanic skin responses in adult humans. *The Journal of psychology*, 61, 153–157
- Nagai, Y., Critchley, H. D., Featherstone, E., Trimble, M. R., & Dolan, R. J. (2004). Activity in ventromedial prefrontal cortex covaries with sympathetic skin conductance level: A physiological account of a "default mode" of brain function. *NeuroImage*, 2, 243-251.
- Naqvi, N. H., & Bechara, A. (2006). Skin conductance: A psychophysiological approach to the study of decision making. In C. Senior, T. Russell, & M. S. Gazzaniga (Eds.), *Methods in mind*. Cambridge: The MIT Press.
- Nichols K. A., & Champness, B.G. (1971). Eye gaze and the GSR. *Journal of Experimental Social Psychology*, 7, 623–626.
- O'Doherty, J., Winston, J., Critchley, H., Perrett, D., Burt, D. M., & Dolan, R. J. (2003). Beauty in a smile: The role of medial orbitofrontal cortex in facial attractiveness. *Neuropsychologia*, 41, 147-155.
- O'Malley, C., Langton, S., Anderson A., Doherty-Sneddon, G., & Bruce, V. (1996). Comparison of face-to-face and video-mediated interaction. *Interacting with Computers*, 8, 177–192.
- Patterson, M. L., & Sechrest, L. B. (1970). Interpersonal distance and impression formation. *Journal of Personality*, 38, 160–165.

- Patterson, Miles L. (1976). An arousal model of interpersonal intimacy. *Psychological Review*, 83, 235–245.
- Perani, D., Fazio, F., Borghese, N. A., Tettamanti, M., Ferrari, S., Decety, J., & Gilardi, M. C. (2001). Different brain correlates for watching real and virtual hand actions. *Neuro-Image* 14, 749–758.
- Pönkanen, L. M., Peltola, M. J., & Hietanen, J. K. (2011). The observer observed: Frontal EEG asymmetry and autonomic responses differentiate between another person's direct and averted gaze when the face is seen live. *International Journal of Psychophysiology*, 82, 180–187.
- Postmes, T., & Spears, R. (1998). Deindividuation and anti-normative behavior: A meta-analysis. *Psychological Bulletin*, 123, 1–21.
- Pyner, S., & Coote, J. H. (1999). Identification of an efferent projection from the paraventricular nucleus of the hypothalamus terminating close to spinally projecting rostral ventrolateral medullary neurons. *Neuroscience*, 88, 949–57.
- Redcay, E., Dodell-Feder, D., Pearrow, M. J., Mavros, P. L., Kleiner, M., Gabrieli, J. D., & Saxell, R. (2010). Live face-to-face interaction during fMRI: A new tool for social cognitive neuroscience *NeuroImage*, 50, 1639–1647 doi:10.1016/j.neuroimage.2010.01.052
- Reddy, V. (2003). On Being the Object of Attention: Implications for Self-Other Consciousness, *Trends in Cognitive Science*, 7, 397–402.
- Rice, R. E. (1993). Media appropriateness: Using social presence theory to compare traditional and new organizational media. *Human Communication Research*, 19, 451–84.
- Rimmele, U., & Lobmaier, J. S. (2012). Stress increases the feeling of being looked at. *Psychoneuroendocrinology*, 37, 292–298.
- Rom, D. M. (1990). A sequentially rejective test procedure based on a modified Bonferroni inequality. *Biometrika*, 77, 663–665.
- Salinäs, E. L. (2005). Effects of Communication Mode on Social Presence, Virtual Presence, and Performance in Collaborative Virtual Environments. *Presence: Teleoperators, & Virtual Environments*, 14, 434–449
- Sawilowsky, S. S. (1990). Nonparametric tests of interaction in experimental design. *Review of Educational Research*, 60, 91–126.
- Scerbo, A. S., Freedman, L. W., Raine, A., Dawson, M. E., & Venables, P. H. (1992). A major effect of recording site on measurement of electrodermal activity. *Psychophysiology*, 29, 241–246.
- Scheier, M. F., & Carver, C. S. (1977). Self-focused attention and experience of emotion: Attraction, repulsion, elation, and depression. *Journal of Personality and Social Psychology*, 35, 625–636
- Sellen, A. (1995), Remote conversations: The effects of mediating talk with technology, *Human-Computer Interaction*, 199, 401–444,
- Senju, A., & Johnson, M.H. (2009). The eye contact effect: Mechanisms and development. *Trends in Cognitive Sciences*, 13, 127–134.
- Senju, A., Hasegawa, T., & Tojo, Y. (2005). Does perceived direct gaze boost detection in adults and children with and without autism? The stare-in-the-crowd effect revisited. *Visual Cognition*, 12, 1474–1496.

- Sequeira, H., Hot P., Silvert L., & Delplanque S. (2009). Electrical autonomic correlates of emotion. *International Journal of Psychophysiology*, *71*, 50–56.
- Short, J. A., Williams, E., & Christie, B. (1976). *The social psychology or telecommunications*. London: Wiley.
- Siegel J., Dubrovsky, V., Kiesler, S., & McGuire, T. W. (1986). Group processes in computer-mediated communication. *Organizational Behavior and Human Decision Processes*, *37*, 157–186.
- Silverman, A. J., Cohen, S. I., & Shmavonian, B. M. (1959). Investigation of psychophysiological relationships with skin resistance measures. *Journal of Psychosomatic Research*, *4*, 65–87.
- Silvia, P. J., & Duval, T.S. (2001). Objective self-awareness theory: Recent progress and enduring problems. *Personality and Social Psychology Review*, *5*, 230–241
- Silvia, P. J., & Eichstaedt, J. (2004). A self-novelty manipulation of self-focused attention for internet and laboratory experiments. *Behavior Research Methods*, *36*, 325–330.
- Silvia, P. J., & Gendolla, G. H. E. (2001). On introspection and self-perception: Does self-focused attention enable accurate self-knowledge? *Review of general psychology*, *5*, 241–269
- Sommer, R. (1965). Further studies in small group ecology. *Psychological Bulletin*, *67*, 145–152
- Sproull, L., & Kiesler, S. (1986). Reducing social context cues: Electronic mail in organizational communication. *Management Science*, *32*, 1492–1513
- Stawarska, B. (2006). Mutual gaze and social cognition. *Phenomenology and the Cognitive Sciences*, *5*, 17–30.
- Stormark, K.M., & Braarud, H.C. (2004), Infants' sensitivity to social contingency: A “double video” study of face-to-face communication between 2- and 4-month-olds and their mothers. *Infant Behavior and Development*, *27*, 195–203.
- Sugenoya J, Iwase S, Mano T, Ogawa T. (1990). Identification of sudomotor activity in cutaneous sympathetic nerves using sweat expulsion as the effector response. *European Journal of Applied Physiology and Occupational Physiology*, *61*, 302–308.
- Teufel, C., Alexis, D., Clayton, N., & Davis, G. (2010). Mental-state attribution drives rapid, reflexive gaze following. *Attention, Perception, & Psychophysics*, *72*, 695–705.
- Teufel, C., Fletcher, P. C., & Davis, G. (2010). Seeing other minds: Attributed mental states influence perception. *Trends in Cognitive Science*, *14*, 376–382.
- Tipper, S. P. (2010). From observation to action simulation: The role of attention, eye-gaze, emotion, and body state. *The Quarterly Journal of Experimental Psychology*, *63*, 2081–2105.
- Toothaker, L. E., & Newman, D. (1994). Nonparametric competitors to the two-way ANOVA. *Journal of Educational and Behavioral Statistics*, *19*, 237–273.
- Tranel, D. (1983). The effects of monetary incentive and frustrative nonreward on heart rate and electrodermal activity. *Psychophysiology*, *20*, 652–657
- Tranel, D. (2000). Electrodermal activity in cognitive neuroscience: Neuroanatomical and neuropsychological correlates. In: Lane RD, & Nadel L. (Eds.). *Cognitive neuroscience of emotion*. (pp 192–224). Oxford University Press.
- Trevino, L. K., Lengel, R. H., & Daft, R. (1987). Media Symbolism, Media Richness, and Media Choice in Organizations: A Symbolic Interactionist Perspective. *Communication Research*, *14*, 553–574.

- Walla, P. (2008). Olfaction and its dynamic influence on word and face processing: Cross-modal integration. *Progress in Neurobiology*, *84*, 192–209.
- Watson, O. M., & Graves, T. D. (1966). Quantitative research in proxemic behavior. *American Anthropologist*, *68*, 971–985.
- Webb, W. M., Marsh, K. L., Schneidermann, W., & Davis, B. (1989). Interaction between self-monitoring and manipulated states of self-awareness. *Journal of Personality and Social Psychology*, *45*, 70–80.
- Vecera, S. P., & Rizzo, M. (2006). Eye gaze does not produce reflexive shifts of attention: Evidence from frontal-lobe damage. *Neuropsychologia*, *44*, 150–159.
- Wicker, B., Michel, F., Henaff, M.A., & Decety, J. (1998). Brain regions involved in the perception of gaze: A PET study. *NeuroImage*, *8*, 221–227.
- Wicker, B., Perrett, D. I., Baron-Cohen, S., & Decety, J. (2003). Being the target of another's emotion: A PET study. *Neuropsychologia*, *41*, 139.
- Wicklund, R.A. (1975). Objective self-awareness. *Advances in Experimental Social Psychology*, *8*, 233–275.
- Wieser, M.J., Pauli, P., Alpers, G.W., & Mühlberger, A., (2009). Is eye to eye contact really threatening and avoided in social anxiety?—an eye-tracking and psychophysiology study. *Journal of Anxiety Disorders*, *23*, 93–103,
- Wilcox, L. M., Allison, R. S., Elfassy, S., & Grelik, C. (2006). Personal space in virtual reality. *ACM Transactions on Applied Perception (TAP)*. *3*, 412–428.
- Wilcox, R. (2011). *Modern Statistics for the Social and Behavioral Sciences: A Practical Introduction*. New York: CRC Press.
- Wilcox, R. R. (2012). *Introduction to Robust Estimation and Hypothesis Testing*, (3<sup>rd</sup> ed). San Diego, CA ; Academic Press.
- Vinayagamoorthy, V., Garau, M., Steed, A., & Slater, M. (2004). An eye gaze model for dyadic interaction in an immersive virtual environment: Practice and experience. *Computer Graphics Forum*, *23*, 1–11. doi: 10.1111/j.1467-8659.2004.00001.x
- Wirth, J. H., Sacco, D. F., Hugenberg, K., & Williams, K. D. (2010). Eye gaze as relational evaluation: Averted eye gaze leads to feelings of ostracism and relational devaluation. *Personality and Social Psychology Bulletin*, *36*, 869–882.
- Zahn, T. P., Grafman, J., & Tranel, D., 1999. Frontal lobe lesions and electrodermal activity: effects of significance. *Neuropsychologia*, *37*, 1227–1241.
- Zahn-Waxler, C., M. Radke-Yarrow, E. Wagner, & M. Chapman (1992). Development of concern for others. *Developmental Psychology*, *28*, 126–136.
- ESBootstrapCorrelated3.exe [Computer software]. (2005). Algina, J., Keselman, H.J., & Penfield, R. Educational and Psychological Measurement.
- PASW STATISTICS.exe, version 18.0 (2010). [Computer software] IBM Solutions
- R.app GUI 1.43 Leopard build [Computer software]. (2004-2011). Urbanaek, S., Bibiko, H-J., & Iacus, S. The R Foundation for Statistical Computing.



# Appendix 1

The used pseudorandom scripts for gaze direction

---

<b>Presentation order</b>	<b>Script 1</b>	<b>Script 2</b>
1	averted	averted
2	straight	straight
3	averted	averted
4	straight	straight
5	straight	straight
6	averted	averted
7	straight	averted
8	averted	straight
9	straight	straight
10	averted	averted
11	straight	averted
12	straight	straight
13	averted	straight
14	averted	averted
15	straight	straight
16	averted	averted

---

# Appendix 2

The used R-source code

```
#source("/Users/maiija/Desktop/Psykologiangradu/tilasto/graduskript.R")
setwd("/Users/maiija/Desktop/Psykologiangradu/tilasto/PASWmatriisit")
library(foreign)
library(akima)
library(robustbase)
library(WRS)
library(psych)
```

```
data <- read.spss("MEANdata.sav", to.data.frame=T, use.missings=T)
head(data, 5)
mean.data <-data[, c(5,6,7,8)]
difference.data <-data[, c(13,14,15,16)]
```

```
bartlett.test (mean.data)
```

```
attach(difference.data)
boxplot(dsuorakääntc,dsuorakääntnc,dcncsuora,dcnckäänt, ylab="paired difference scores of
SCR-response magnitude", names=c("dgaze c", "dgaze nc", "dcam direct", "dcam averted"),
las=1,col="grey", boxwex=.5, ylim=range(c(-.5,.5)),medcol="white")
plotmeans(formula, data=difference.data, subset, na.action, bars=TRUE, p=0.95, minsd=-2,
minbar, maxbar,xlab=names(mf)[2], ylab=names(mf)[1], mean.labels=FALSE, ci.label=FALSE,
n.label=TRUE, digits=getOptio ("digits"), col="black", barwidth=1, barcol="gray", connect=TRUE,
ccol=col, legends=names(means), xaxt, use.t=TRUE)
detach(difference.data)
```

```
wwtrim(2,2,mean.data)
wwmcppb(2,2,mean.data, plotit=T)
```

```
samdata <- read.spss("sam.sav", to.data.frame=T, use.missings=T)
SAM_1.data<-samdata[, c(4,7,10,13)]
wwtrim(2,2,SAM_1.data)
wwmcppb(2,2,SAM_1.data)
SAM_2.data<-samdata[, c(5,8,11,14)]
wwtrim(2,2,SAM_2.data)
wwmcppb(2,2,SAM_2.data)
```

```
r.test(17, r12=-.257, r34=-.203, r23=.04, r13=.578, r14=-.223, r24=.57)
#steiger case B (Steiger, J. 1981)
r.test(n,r12=rSCRC*SAMC,r34=rSCRNC*SAMNC,r23=rSAMC*SCRNC,r13=rSCRC*SCRNC, r14
= rSCRC*SAMNC, r24 = SAMC*SAMNC, n2 = n1,pooled=TRUE, twotailed = TRUE)
```

```
presence.data<-samdata[, c(16,17)]
bartlett.test(presence.data)
rmmcppb(1,1,presence.data)
```

```
ssas.data<-samdata[,c(18,19,20,21,22,23)]
ssaspublic.data<-samdata[, c(18,19)]
ssassurroundings.data<-samdata[, c(20,21)]
ssasprivate.data<-samdata[, c(22,23)]
bartlett.test(ssaspublic.data)
bartlett.test (ssassurroundings.data)
bartlett.test (ssasprivate.data)
```