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Physiological changes during first encounters and their role in determining the perceived interaction quality.

Konrad Rudnicki[1*], Carolyn Declerck[2], Charlotte De Backer[1], Mario Berth[3]

1- Universiteit Antwerpen, Department of Communication Science.

2 – Universiteit Antwerpen, Faculty of Applied Economics.

3 – Algemeen Medisch Laboratorium, Antwerpen.

- \- corresponding author. Kipdorp 61, 2000, Antwerpen, Belgium. Email: konrad.rudnicki@uantwerpen.be

Abstract

What determines if the first interaction between strangers will be a pleasant experience? We conducted an experiment to investigate the extent to which the perceived quality of an interaction is influenced by conversation content and context, and we document the physiological changes that are likely to play a role in establishing rapport. Females who did not know each other met in pairs and conducted a gossip- or creativity task, either face-to-face or online. The conversation content had no effect on the quality of online interactions. However in the face-to-face condition gossip was associated with better interaction quality. Tonic electrodermal activity steadily declined throughout the interaction, while phasic electrodermal activity first peaked and then returned to baseline. Neither were related to perceived interaction quality. Heart rate variability (HRV) dropped at first but then remained stable. A smaller drop in HRV drop corresponded to higher ratings of rapport and liking. Together these results suggest that gossip can improve the quality of a face-to-face interaction between strangers, and support the conjecture that parasympathetic activity is a marker of human openness to social engagement.

Keywords: Social interaction, Autonomic Nervous System, Heart Rate Variability, Skin Conductance, Oxytocin, Gossip, Mediated Communication

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1. Introduction

Social interactions evoke many psychological and physiological changes which may play a role in determining if two people who just met will like each other (Warner, 1996). During the first encounters, the human brain is highly efficient at processing social information in order to decide if someone is an adversary or could potentially be a friend (Insel and Fernald, 2004). One of the processes that make this so efficient is interoception – a phenomenon by which information processing in the central nervous system benefits from signals generated by the current state of the body (Critchley, 2013).

The idea that the physiological state drives human emotions and behavior originated with the theory of James and Lange (1922), who suggested that heart rate, body temperature and other visceral phenomena precede emotional states and determine them. Since then, much research has shown that physiological reactions in the body coincide with emotional processing in the brain, and that patterns in peripheral physiology can be predictive of human affective states and subsequent behavior (Critchley, 2013). For example, some researchers have already compiled maps of bodily sensations triggered by specific emotions (Nummenmaa et al., 2014). Others try to characterize different patterns of physiological responses during social interactions by studying autonomic activity (Dawson et al., 2007; Shahrestani et al., 2015). An increase in parasympathetic activity has been associated with positive emotionality and approach behaviors which are likely to translate into better interaction quality (Shahrestani et al., 2015). In contrast, an increase in sympathetic activity can be used as a marker of stress experienced during social interactions (Dawson et al., 2007).

Thus, by studying the activation of the autonomic nervous system together with the perceived interaction quality in different settings, we can learn if they are related and how they change dependent on the circumstances. The purpose of this study is to investigate if, and how, the circumstances of a first encounter between two strangers trigger physiological changes and affect the perceived quality of the interaction. We focus on two aspects of social interactions that could potentially have a great impact on the perceived subjective quality: first we compare the reported quality of the interaction in a context where both parties are physically present (facing one-another) versus one in which the encounter is online. Second, we investigate the influence of the content of the conversation during the encounter. We refer to the former as the social context, and the latter the conversation content of the interaction, and for each we develop specific hypotheses based on the existing literature.

1.1. The influence of context and content on social interaction quality.

When two strangers meet face-to-face, their interaction is rich in contextual cues (e.g., body language) which can be used as a source of social information (Bicchieri and Lev-On, 2007; Bos et al., 2002). Visual cues, and especially eye gaze, convey information about the social status and emotional state of the interaction partner (Emery, 2000). Processing of these cues happens in highly specialized areas of the brain, and may well be one of the major foundations for effective social cognition (Itier and Batty, 2009). Experimental evidence corroborates that in real-life social interactions humans base their trust on the appearance of their interaction partner (Duarte et al., 2012). In contrast, viewing only still pictures of eyes may not be sufficient to affect behavior (Fehr et al., 2010). Computer-mediated interactions without visual cues convey less social information since they do allow the benefit of facial expressions, body language and spatial dynamics. As a result, computer mediated communication has been shown to decrease the interaction quality in group settings (Baltes et al., 2002) and led to an observation that online interactions are less efficient at creating bonds between people (Cummings et al., 2002). Therefore, one might expect that face-to-face social interactions improve the interaction quality between two strangers compared to online interactions (Hypothesis 1A).

However, seeing the eyes of another person is especially effective at inducing arousal (Andreassi, 2000; Conty et al., 2010). Gaze is a potent social stimulus that could signal either aggression or kindness (Kleinke, 1986). Therefore, the effects of interacting face-to-face could also go the other way: if face-to-face interactions induce arousal which in turn causes a drop in parasympathetic activity (Shahrestani, 2015), this combined effect might decrease the interaction quality and lead to social withdrawal (Hypothesis 1B). Thus, it is an open question in which direction the context of the interaction (face to face vs online) will influence the quality of the first encounter between two strangers.

In addition to the presence of visual cues, the conversation topic during a first encounter (content) could also determine the emergent interaction quality. Topics that provide a large amount of social information, such as gossip, have been hypothesized to increase interaction quality (Dunbar, 2004). Foster (2004) defines gossip as “exchange of personal information (positive or negative) in an evaluative way (positive or negative) about absent third parties.” Interpersonal gossip (i.e., gossiping about peers) was shown to enhance in-group cooperation in social dilemma games (Boero et al., 2009; Feinberg et al., 2012; Piazza & Bering, 2008;

Sommerfeld et al., 2007, 2008). Furthermore, in computer simulations of social behavior gossip facilitated the emergence of cooperation and helped to maintain it (Mitchell et al., 2016). Gossip was also proposed to decrease stress (Waddington and Fletcher, 2005), since it may mimic the relaxing, physiological effects of grooming in primates (Dunbar, 2004) by increasing the levels of anxiolytic hormones, such as oxytocin (Brondino et al., 2017). Therefore, we hypothesize that conversations that encourage people to gossip will have a more positive effect on the interaction quality between two strangers compared to conversations that do not involve talking about others, but instead draw attention towards the self (Hypothesis 2). To accomplish this, we introduce a joint creativity task whereby the creative ideas of interacting individuals are implicitly subjected to mutual evaluation. Thus, the task elicits some social pressure to perform in a way that reflects one's own cognitive capacities. This contrasts sharply with a gossip task where interacting individuals are exchanging positive or negative evaluative judgments about third parties. Because the interacting parties do not know each other, we rely on celebrity gossip in particular, as it is a type of gossip where strangers in artificial laboratory environments can still have a mutually known person to talk about. When people gossip about celebrities, they typically learn about the norms and moral standards of their interlocutor (Gorin & Dubied, 2011). Celebrity gossip can provide a rich source of social information, similarly to interpersonal gossip, which facilitates friendship formation and bonding (De Backer et al., 2007; De Backer & Fisher, 2012).

These postulated effects of gossip, as well as face-to-face interactions, may trigger changes in physiology that further affect the perception of the social encounter. The second aim of this study is therefore, to investigate if changes in physiology are related to the reported quality of the interaction, and to test if they mediate the postulated effects of gossip and the physical presence of the other person.

1.2. Peripheral physiology and interaction quality.

1.2.1. Parasympathetic activity and interaction quality. The most important component of the parasympathetic nervous system is arguably the vagus nerve, with 80% of its fibers relaying sensory information from the body to the brain (afferent fibers) (Petrovicky et al., 2011). The vagal nerve plays a crucial role in regulating human social interactions because it simultaneously collects interoceptive information with its afferent fibers, while also regulating physiological state with its efferent fibers (Porges, 2003). During social interactions, when conditions are perceived to be safe, vagal activity increases, which diminishes anxiety by lowering cardiovascular activity. This suppresses the fight-or-flight response by inhibiting activity of the hypothalamo-pituitary-adrenal axis (HPA) (Porges, 2007), leading to improved interoception and increased social approach. Furthermore, the same brain nuclei that govern efferent vagus activity are also responsible for regulating facial and head muscles. As a result, a calm bodily state associated with increased vagal tone during social interactions also affects facial expressions, eye gaze and prosody, regulating the visual cues that are potentially picked up by interacting partners (Porges, 2001).

In order to relate parasympathetic activity to different aspects of social interactions, researchers have used a measure of heart rate variability (HRV) as a proxy for vagal activation (Acharya et al., 2006). A body of research already showed that higher HRV is related to more interpersonal warmth (Diamond and Cribbet, 2012), positive affect (Diamond et al., 2011) and cheerfulness (Geisler et al., 2010) during social interactions. People with higher HRV create bonds faster, which in turn increases their HRV even more in a positive-feedback loop (Kok and Fredrickson, 2010). Furthermore, since HRV indicates increased parasympathetic activation, it is also likely to facilitate the processing of interoceptive information, as corroborated by its positive correlation with emotion recognition (Quintana et al., 2012). Overall, HRV is now thought to be a biomarker of effective emotion regulation (Hastings et al., 2008; Lewis et al., 2006; Porges, 2007; Thayer and Lane, 2000), which allows for more positive emotionality in social interactions. Therefore, we hypothesize that HRV will be also positively related to the interaction quality between strangers (Hypothesis 3).

1.2.2. Sympathetic activity and interaction quality. While an increase in parasympathetic activity is thought to facilitate social approach, both the parasympathetic and the sympathetic branches of the autonomic nervous system are involved in regulating physiological response to social stimuli (Porges, 2001). These two branches act antagonistically: therefore arousal can be caused by parasympathetic deactivation, or sympathetic activation. Sympathetic activation is associated with the fight-or-flight response, and its occurrence during a social interaction causes social anxiety and promotes withdrawal (Critchley, 2002). As a result, sympathetic activation, operationalized as electrodermal activity (EDA), is typically used as a marker of stress (Dawson et al., 2007). It can be divided into two components that capture slightly different aspects of arousal: a tonic EDA, which is indicative of a slowly-changing general level of arousal and sympathetic activity (Boucsein, 2012), and a phasic component, which signifies rapid autonomic reactions to a stimulus (Benedek et al., 2010a). In contrast to HRV, which is associated with effective emotion regulation and expression, higher tonic and phasic EDA are linked to emotional suppression (Gross and Levenson, 1993), as well as to greater social anxiety (Nikolić et al., 2016;

Wu et al., 2013). Because of this, we hypothesize that higher EDA activity (both phasic and tonic) will be negatively related to interaction quality between strangers (Hypothesis 4).

1.2.3. Peripheral oxytocin and interaction quality. In addition to the role of the autonomic nervous system, there are also endocrine factors that are likely to regulate the interaction quality between strangers. Lately, much attention has been given to the role of oxytocin, a nanopeptide with a well-documented role in mammalian reproduction. Within the central nervous system, oxytocin functions as a neurotransmitter and promotes affiliative behavior (Ross & Young, 2009), reduces anxiety (MacDonald & Feifel, 2014), and enhances the salience of social cues (Shamay-Tsoory, & Abu-Akel, 2016). In the brain these effects of oxytocin all have the potential to increase the interaction quality between people and facilitate approach behaviors when conditions are appropriate (Lambert et al., 2017). However, oxytocin is also released peripherally from the pituitary into the blood circulation, where it functions as a hormone. Such release was demonstrated when parents play with their children (Strathearn et al., 2009), friends share a secret (Keri & Kiss, 2011), or lovers hold their hands (Grewen et al., 2005). oxytocin release in these circumstances is thought to lower heart rate and decrease blood pressure, thereby reducing arousal and social anxiety (Churchland & Winkielman, 2012; Grewen and Light, 2011). oxytocin also enhances parasympathetic activity, thus promoting approach behaviors (Quintana et al., 2013). Due to these autonomic effects, an increase in peripheral oxytocin might potentially be one of the factors determining if two strangers will like each other on first encounter. We hypothesize that higher release of oxytocin during an interaction between two strangers will be positively related to the resulting interaction quality (Hypothesis 5).

1.3. Peripheral physiology mediates the relation between the properties of an interaction and the reported quality of that interaction.

Changes in peripheral physiology are relayed to the brain via the vagus nerve and co-regulate the course of social interactions (Critchley, 2013). This implies that successfully perceiving one's own bodily state via interoception is part and parcel of successful social interactions. Figure 1 combines hypotheses 1-5 into a mediation model, proposing that the changes in peripheral physiology are in fact responsible for determining how two strangers will perceive the quality of their first interaction (Hypothesis 6). For example, if gossip in the conversation leads to lower levels of stress (measured with EDA), the mediation model would suggest that the lowered stress in turn would improve ratings of interaction quality.

Insert Figure 1.

2. Materials and methods

2.1. Design.

A 2x2 factorial experimental design was used to test the influence of social context and social content on the quality of interaction between two strangers. To manipulate context two participants interacted either face-to-face or online with audio-, but without video access. To manipulate content they performed either a joint gossip- or creativity task. The participants were specifically instructed to "discuss controversial or admirable behaviors of these celebrities" (gossip), or to "Come up with creative uses for those objects" (creativity). The items for the task were selected based on pilot studies during which twenty dyads of participants discussed 60 pictures of either celebrities or common household objects. Afterwards participants of the pilots were interviewed to find out what they talked about. For the gossip, we settled on 20 pictures of celebrities that evoked the most gossip and for the creativity task we settled on 20 pictures of objects that never evoked discussion of other people. Because the essence of gossip is to exchange evaluative information about other people, the creativity task needed to be devoid of this type of information exchange.

To collect data on physiological measures, we recorded continuously the heart rate and electrodermal activity of the participants, from which sympathetic and parasympathetic activity can be derived. We also collected saliva samples before and after the interaction to measure oxytocin levels.

This study is a part of a bigger project designed to study the psychobiological and social effects of gossip. In a separate article we analyze how individual differences in the personality trait social value orientation moderate the effects of gossip on trust between strangers ([redacted]). The hypotheses tested in that work are unrelated to the hypotheses regarding the physiological recordings and interaction quality measures reported in this paper.

2.2. Participants.

All 122 participants were female students from the University of Antwerp, recruited via posters and online announcements. Previous studies demonstrated that physiological responses can differ as a function of social distance between the interacting people (i.e. it is more physiologically arousing to interact with someone of higher social standing) (Cordonier et al., 2017), therefore all the participants in our study were required to be university students.

Registration occurred via an online platform and was voluntary and incentivized with monetary remuneration. We decided to conduct the experiment only with female participants because there are significant sex differences in gossip (Levin and Arluke, 1985) and oxytocinergic reactivity (Carter, 2007). Furthermore, analyzing interactions of both sexes at once would yield three types of interactions (male-female, male-male and female-female) effectively tripling the statistical power required for the analysis.

The experiment was conducted in dyads, (pairs of participants) and each dyad was randomly assigned to one of the four possible conditions (face-to-face gossip, face-to face creativity, online gossip, online creativity). Data of four dyads (N=8) were excluded from the analysis, because, in a post-experimental questionnaire, these participants admitted to knowing each other prior to the experiment. Mean age of the participants was 21.96 (SD=2.57, Median=22). Age of the participants was not significantly different between the experimental conditions $F(3, 110) = 1.33$, $p= .27$

2.3. Procedure.

Two participants at a time were invited to separate meeting points to avoid that they would see each other before the experiment. After arrival participants were separately escorted by experimenters to their respective rooms in the laboratory where they signed an informed consent form. Participants were instructed to turn off their electronic devices and not use them for the duration of the experiment. Next, participants wore an Empatica E4 wristband equipped with a pair of steel electrodes for the EDA recording and photopletysmographic sensor for heart rate recording. The experimenter then left the room and participants sat alone in their respective rooms for 10 minutes in order to collect baseline physiological recordings and fill out pre-experimental questionnaires.

After the 10 minute waiting period, participants provided the first saliva sample. Next, in the face-to-face condition, the two participants were escorted to a common room to complete their joint task. They talked while sitting at the same table facing each other. In the online condition, participants remained in their separated rooms and talked via online voice communicator (Skype). In the gossip condition participants received twenty pictures of widely known celebrities and were instructed to discuss their controversial or admirable behavior. In the control condition participants received twenty pictures of common household objects and were instructed to come up with creative ways to use those objects. In all conditions, the experimenter read the instructions out loud and then left the room. The task lasted for 20 minutes, after which the experimenter came back and escorted the participants back to their separate rooms. Finally, participants filled-out the post-experimental forms, removed Empatica devices, provided a second saliva sample, and received compensation for participating in the experiment.

2.4. Measuring interaction quality.

To capture a broad scope of interaction quality in this study we measure rapport, cohesion and likability of the task. We also measure participants' mood change during the interaction.

Rapport is a property of a social interaction that encompasses positive affect, mutual focus of attention of interacting parties and interpersonal coordination (Tickle-Degnen and Rosenthal, 1990). In particular, rapport can be described as interpersonal synchrony or harmony (Gillis and Bernieri, 2001). Rapport was measured after the task with the 18-item Rapport Questionnaire, which is a validated method used for that purpose (Bernieri et al., 1994; Bernieri, 2005). Cronbach alpha observed in our sample indicated high reliability of this questionnaire (α=

0.89). The total rapport score was calculated as a sum of all 18 items of the Rapport Questionnaire, following the instructions of the authors (Bernieri, 2005).

Social cohesion is defined as the perceived closeness of one person to another (Agnew et al., 2004). It was measured after the task with Inclusion-of-other-in-self scale (IOS) (Aron & Smollan, 1992) a single-item question where participants pick one of the seven Venn-like diagrams showing increasingly overlapping circles. One circle represents the self and other represents the other participant. IOS is typically used as operationalization of the social cohesion (Buton et al., 2007; Tropp & Wright, 2001).

Likeability of the task was measured with a single-item question: “How much did you like the task?” on a Likert scale.

Finally, mood was measured both before and after the task with The Positive and Negative Affect Schedule (PANAS) (Watson et al., 1988). It consists of 20 items (pre-experimental $\alpha=0.73$, post-experimental $\alpha=0.79$), and allows to separately assess levels of positive and negative affect. General mood value is derived by subtracting the sum of negative affect items from the sum of positive affect items.

2.5. Physiological measurements.

Heart rate was recorded by using photopletysmographic measurements of blood volume pulse (BVP) with an Empatica E4 wristband worn on the non-dominant hand at a sampling rate of 64Hz. Collecting physiological measurements with a discrete wristband instead of classical electrocardiogram or galvanometer allows for a more natural environment during the interaction, which follows the recently proposed enhancements to the experimental protocols of studies on social interactions (Chaminade, 2017).

To derive heart rate variability (HRV) R-peaks were detected using Kubios HRV software (Biomedical Signal Analysis Group, Department of Applied Physics University of Kuopio, Finland). To remove trend components, data were detrended following the procedure based on smoothness priors approach (Tarvainen et al., 2002; Tarvainen and Niskanen, 2008). The smoothness parameter was set at 500 ms. A unitless HRV triangular index was obtained for 5-minute segments, as the integral of the histogram (i.e. total number of RR intervals) divided by the height of the histogram with a bin width of 1/128 seconds (Camm et al., 1996).

Electrodermal activity (EDA) was measured with an Empatica E4 wristband at a sampling rate of 4Hz, which is the maximum sampling rate of this device. Given that we are not analyzing event-related EDA activity and that we are measuring over relatively long periods (5min.) a sampling rate of 4Hz is sufficient and conforms to the Nyquist theorem that requires sampling at at least twice the frequency of expected events. In the current experiment, the maximum observed frequency of phasic events was 0.21/sec, which is well below 4Hz. The accuracy of Empatica E4 was also recently corroborated in a study comparing its measurements to those performed with laboratory sensors (Ragot et al., 2017).

The EDA signal was decomposed into two sub-components: tonic and phasic EDA. Both measures were obtained by using continuous decomposition analysis with Ledalab software following the procedures devised by Benedek et al. (2010b), and averaged over 5-minute segments. Data from the wristbands was manually inspected to ensure the presence of uninterrupted signal, as the electrodes and sensors in wristbands are not glued to the skin as in traditional methods. In 4 participants Empatica failed to record BVP levels without interruptions, and in 22 participants it failed to register the EDA signal without interruptions. Interrupted signals were recorded as missing data.

To assess salivary oxytocin levels, saliva was collected into plastic eppendorf tubes. Samples were immediately put in a freezer at -24 °C and kept for no longer than two weeks until assayed. The oxytocin assays were performed at the Algemeen Medisch Laboratorium Antwerpen. Saliva samples were extracted following an established acetone-ether method: 1 ml of saliva was mixed with two volumes of acetone, and the supernatant was saved and washed with two volumes of anhydrous ether (Amico et al., 1985). After the ether phase was removed, the remaining extract was dried with nitrogen and reconstituted in 300µl of the assay buffer. A commercially available enzyme immunoassay (EIA: Enzo Life Sciences Inc., Farmingdale, NY) was used for the analysis of oxytocin levels. This assay is specific with respect to the cross-reactivity between oxytocin and arginine vasopressin < 0.04% (Rubin et al., 2014). The assay was performed following the manufacturer's protocol. Salivary oxytocin levels ranged from 2 to 176.6 pg/ml, with a mean of 39.25 (SD = 27.4), which is in line with concentrations obtained in past studies using this particular extraction method (Kagerbauer et al., 2013). The inter-assay coefficient of variation of the calibration curve samples was 12.77%. However, the inter-assay coefficient derived from comparing the same biological sample in each assay was 43.93%. The mean intra-assay coefficient of variation was 27.75%. The inter-assay coefficient of variation is an expression of consistency between measurements performed on different plates, whereas the intra-assay coefficient of variation describes the consistency of repeated measurements of each individual sample within a given plate. Due to these unacceptable values of the coefficients of variation, we consider the oxytocin data unreliable. We report the mean values in the descriptive statistics, but we do not interpret them further and do not include them in the mediation analyses.

2.6. Variables.

The main independent variables are: conversation content (1 – gossip condition, 0 – control condition) and social context (1 – face-to-face, 0 – online). The main dependent variables are rapport, cohesion, likeability, and change in mood. Rapport values can range from 0 to 144, depending on the answers in Rapport Questionnaire. Cohesion can range from 1 to 7, depending on the answer in the IOS. Likeability can range from 1 to 5, depending on the answer in a single-item question. Change in mood was calculated as the difference between general mood before and after the task. Physiological dependent variables are: HRV, tonic EDA and phasic EDA, and oxytocin concentrations measured before (baseline) and after the interaction.

3. Results

Descriptive statistics are presented in Table 1. Correlations between the study variables are presented in Table 2. All of the different measures of interaction quality were positively inter-correlated and also positively correlated with the change in mood. Correlations between the physiological variables and interaction quality are further described in section 3.3.

Insert Tables 1 and 2

3.1. The effect of context and content on interaction quality (Hypotheses 1 & 2).

The mean level of rapport, cohesion, likability, and mood change for each of the four experimental conditions is shown in Figure 2. Visual inspections reveals a trend for every interaction quality measure to be the lowest in the creativity, face-to-face condition.

A linear regression (GLS – random effects model in STATA) was used to determine if the effect of social context (face-to-face vs online) and conversation content (gossip vs creativity) on the measures of interaction quality is statistically significant.

Because participants interacted with each other, the interaction quality for every individual participant was influenced not only by the experimental conditions, but also by their interaction partner. As a result, their answers in questionnaires cannot be treated as independent from each other. Therefore, the data was analyzed as a panel of 114 individuals clustered in 57 pairs, where every pair of participants constitutes a separate unit of analysis in the regression (using the XTREG command in STATA). This method takes into account the additional heterogeneity of the perceived interaction quality of each pair. As a result, no information is lost as it would be when aggregating answers of two participants into single data points. Robust standard errors of the coefficients are reported, using the sandwich estimators developed by Huber (1967) and White (1982). Because social context and conversation content are dichotomous variables we report unstandardized regression coefficients (Darlington and Hayes, 2017).

Insert Figure 2

The results of two regression models are shown in Table 3: the first one tests for the main effects of gossip and face-to-face interactions, while the second one adds their interactive effect. Two significant main effects are revealed. In the first model, a negative main effect of face-to-face interactions on rapport emerges (Figure 2a). This main effect stays significant after adding the interaction term. This provides partial evidence in favor of hypothesis 1B that interactions face-to-face elicit lower interaction quality. Second, a positive main effect of gossip on likeability is found in model 1. However, from model 2 it we can derive that this effect is driven by an interaction with social context. From Figure 2c we can infer that the face-to-face creativity task was liked the least. Model 2 also reveals a significant interaction effect on cohesion, showing again that the face-to-face, creativity task leads to the least cohesion (Figure 2b). Therefore, hypothesis 2, stating that gossip elicits higher interaction quality, needs to be nuanced to account for these interactions. We found no main effect of gossip on interaction quality. However, we find an interaction effect of gossip and anonymity: gossip may results in higher quality of an interaction, but only when the interaction is occurring face-to-face.

Insert Table 3

3.2. Changes in physiology as a result of the social interaction.

Before testing if the physiological variables mediate the effect of gossip and face-to-face interactions on the quality of an interaction, an ANOVA with repeated measures was performed to check if HRV, tonic EDA and phasic EDA change during the social interaction, irrespective of the experimental condition. For HRV and EDA, measurements are computed for the baseline condition and for the first three 5-minute intervals during the interaction.

The distributions of the HRV, tonic and phasic EDA were tested with Shapiro-Wilk tests, which confirmed that they did not deviate from normality in any of the 4 experimental conditions: gossip face-to-face (HRV: $W = 0.94$, $p = 0.66$; tonic EDA: $W = 0.94$, $p = 0.65$; phasic EDA: $W = 0.97$, $p = 0.90$), creativity face-to-face: (HRV: $W = 0.94$, $p = 0.68$; tonic EDA: $W = 0.92$, $p = 0.55$; phasic EDA: $W = 0.90$, $p = 0.39$), gossip online (HRV: $W = 0.93$, $p = 0.42$; tonic EDA: $W = 0.86$, $p = 0.08$; phasic EDA: $W = 0.93$, $p = 0.42$), creativitiy online (HRV: $W = 0.96$, $p = 0.80$; tonic EDA: $W = 0.90$, $p = 0.40$; phasic EDA: $W = 0.88$, $p = 0.25$). Greenhouse-Geisser corrections in the univariate ANOVA tests were applied due to violation of the covariance matrix sphericity assumption [HRV: $\chi 2$ (5) = 12.16, p < .05; tonic EDA: $\chi 2$ (5) = 104.92, p < .01; phasic EDA: $\chi 2$ (5) = 358.64, p < .01].

The results show that there is a significant change over time in every autonomic measure during the social interaction (Table 4). HRV is lower during the interaction compared to baseline and remained stable throughout the interaction (Figure 3). Phasic EDA peaks during the first 5 minutes of the interaction and returns to the baseline afterwards (Figure 4). Tonic EDA steadily declines to reach its lowest point during the 3rd 5 minutes of the interaction (Figure 5).

Insert Table 4 and Figures 3,4,5

Next, we tested with a repeated measures ANOVA if the change in physiology differs as a function of the experimental conditions. Even though it appears from Figure 3 that the rate at which HRV drops seems to differ between the groups, these differences are not statistically significant, F(3, 105) = 1.07, p = .36. Similarly, the peak in phasic EDA during the first 5 minutes (Figure 4) is not statistically different between the experimental conditions, F(3, 87) = .85, p = .47. However, the drop in tonic EDA throughout the interaction is most visible in the face-to-face groups, F(3, 267) = 3.27, p < .05. From Figure 5 it appears that the difference in tonic EDA between the face-to-face and the online condition becomes greater as time elapses, and is statistically significant in the third interval (t-student test for independent samples), t(89) = 2.67, p < .01.

3.3. Correlations between physiological variables and interaction quality (Hypotheses 3-5).

Because HRV drops immediately after the start of the interaction and then remains stable, we use the mean HRV value of the entire interaction period for the correlational and mediation analyses. For tonic and phasic EDA we use the values for the time intervals that differ the most from baseline: 1st five minutes of the interaction for phasic EDA, and 3rd five minutes of the interaction for tonic EDA.

In accordance with the hypothesis 3, the change in HRV throughout the entire interaction is positively correlated with rapport: $\rho(110) = .24$, $p < .05$, and likeability: $\rho(110) = .20$, $p < .05$, but not with cohesion or change in mood. A higher HRV value indicates a smaller drop, which makes it easier to establish rapport and like the task. A detailed analysis of this correlation at a group level shows that rapport was positively related to HRV in all conditions (Gossip face-to-face: $\rho(28) = .44$, $p < .05$; Gossip online: $\rho(28) = .46$, $p < .05$; Creativity online: $\rho(27) = .56$, $p < .01$), except for creativity face-to-face where HRV and rapport are unrelated: $\rho(27) = -.28$, $p = .17$.

Contrary to the fourth hypothesis neither the change in tonic EDA, nor the change in phasic EDA correlated with any of the measures of the social interaction quality.

3.4. Mediation analysis (Hypothesis 6).

To test the hypothesis 6 that the effects of social context and conversation content are mediated by changes in physiology, we conducted mediation analyses using the PROCESS plugin for IBM SPSS (Hayes, 2013). We limit ourselves to testing two models based on the results of the initial regression analyses. First, we test the mediation of the influence of social context on rapport because it was the only significant main effect that remains significant after including interaction effects in the regression model (Table 3). Next, in line with the interactive effect of gossip face-to-face condition in Table 3, we analyze the influence of content on likeability, but only for face-to-face interactions.

Figure 6 presents the results of the mediation analysis for the effect of social context on rapport. It corroborates the negative main effect of the face-to face context on rapport, as well as the negative association between the face-to-face context and the change in tonic EDA. Specifically, in face-to-face interactions where rapport is lowest, tonic EDA drops faster. However, no mediation by any of the physiological variables is present.

Insert Figure 6

Figure 7 depicts the mediation model of gossip in face-to-face interactions on likeability. It corroborates the positive main effect of gossip on likeability, however no mediation by any of the physiological variables is present.

Insert Figure 7

4. Discussion

The aim of this study was to investigate social and physiological determinants of the perceived quality of interactions when two females meet for the first time. We had pairs of strangers either perform a creativity- or celebrity gossip task. These tasks were performed either face-to-face or online with audio only. The results show that interacting with a stranger in these tasks affects several physiological parameters. During the first 5 minutes of the interaction, parasympathetic activity (HRV) significantly drops, while sympathetic activity (phasic EDA) sharply rises. We interpret this as an increase in arousal or stress associated with meeting a stranger. At the same time people who retained higher HRV experienced better rapport. This correlation was found in three of the four conditions, but not in the face-to face creativity, where the interaction quality was systematically perceived to be lower (see results section 3.3). As HRV is a marker of emotion regulation and homeostatic control (Hastings et al., 2008; Lewis et al., 2006; Porges, 2007; Thayer and Lane, 2000), these results suggest that having effective control over one's emotions when initially meeting a stranger can eventually lead to enhanced rapport. We next discuss these results in more detail with respect to each hypothesis proposed in this study.

First, face-to-face interactions offer visual cues that provide vital social information which, on the one hand, may facilitate approach (Bicchieri and Lev-On, 2007; Bos et al., 2002), but, on the other hand, also induce stress (Andreassi, 2013; Conty et al., 2010). The data seems to partially support the latter (supporting hypothesis 1B), since rapport was lower in face-to-face interactions.

Next, we hypothesized that celebrity gossip might be more efficient at inducing a high quality interaction compared to a creativity task where no discussion about other people is present (hypothesis 2). The reason behind this is that celebrity gossip is often experienced as relaxing and that it stimulates bonding through the act of jointly evaluating absent third parties (De Backer et al., 2012). The creativity task, instead, draws attention to the participants' own performance so that they themselves may have felt implicitly evaluated by their partners. While the data could not corroborate a main effect of gossip on interaction quality, gossip did interact significantly with context (see Table 3), showing that during the face-to-face condition, celebrity gossip was be more efficient at eliciting a high quality interaction between two-women during their first encounter. Alternatively, the interactive effect could mean that performing a joint creativity task (which may be cognitively more demanding compared to gossip) with an unknown other is less disconcerting when conducted online. Possibly, at least for women, the social pressure to perform cognitively face to face is more pronounced than online. These data are of interest in the light of research on assessment centers for job recruitment or team assembly. The results suggest that requiring a cognitive task from two women who just met could prevent them from taking an immediate liking to each other, but that this effect may be alleviated by allowing for some gossiping social talk.

The proposition that interaction quality is positively related to parasympathetic activation (hypothesis 3) was also corroborated, as we found that rapport and likeability increased together with higher overall HRV levels. Furthermore, better rapport was associated with a smaller drop in HRV at the beginning of the interaction. Past studies have shown that HRV drops during “negative” interactions (e.g. stress tasks), but that it doesn’t change during “positive” interactions (e.g. talking to a significant other, Shahrestani et al., 2015). Because meeting a stranger in a laboratory environment is more likely on the stressful side, it is not surprising that HRV in our experiment significantly dropped for everyone at the beginning of the interaction. However, those individuals who are able to limit this initial drop and retain a higher HRV may have been able to perceive the interaction as more positive (Diamond and Cribbet, 2012; Diamond et al., 2011; Geisler et al., 2010), which in our study led to more rapport. However, as we found that neither social context, nor conversation content had any effect on HRV, the mediation model in Figure 1 could not be supported.

Despite the lack of mediation, we note that the significant correlations between HRV levels and rapport hold in every group but one, namely the creativity face-to-face condition, which is also the one group where rapport is significantly lower. We interpret this to mean that the combination of a cognitively more demanding creativity task in a face-to-face condition is the only condition in our experiment where parasympathetic activation does not contribute significantly to the participants' assessment of their interaction quality. This interpretation rests on the postulated mechanism by which peripheral physiology is thought to guide human bonding. Porges (2007) explains that, when the environment is perceived to be safe, the increased vagal activity promotes social engagement by dampening the stress response, decreasing arousal and enhancing human ability to read and express emotions. Through interoception, the positive feelings that emerge at the onset of a meeting between two strangers, might lead to better rapport. In turn, the improved rapport can further reinforce the initial perception that the environment/and or the interaction partner is safe. The final result is a positive feedback loop, where liking someone or something in the first place leads to a cycle of physiological and behavioral reactions that reinforce each other (i.e. "biobehavioral loop," see Feldman et al., 2010; Lopatina et al., 2013).

In line with Porges' theory, the degree to which HRV in each condition contributed to rapport via interoception could have varied. When conditions from the onset are prone to performance judgement and not conducive to engage in social bonding (e.g., when conducting a creativity task in an arousing, face-to-face environment), interoception may contribute little to the perception of the interaction partner, or to the way the interaction is proceeding. In this case, no correlation between HRV and rapport is expected. When interoception is able to contribute to social perception, as during gossip or in a safe online environment, HRV does correlate with rapport. Thus, with respect to hypothesis 3, the finding that the strength of the correlations between HRV and rapport differs across conditions (and is lowest in the creativity face-to-face group) provides indirect evidence that the vagal system constitutes a physiological basis for human ability to engage in social behavior by regulating the extent to which interoception is taking place.

The negative effect of sympathetic nervous system activity on interaction quality was not confirmed (hypothesis 4), as we found no correlation between either tonic or phasic EDA and any of the interaction quality measures, and we also did not find that EDA was higher in the face-to-face creativity task, the task which elicited the lowest rapport. In fact, the opposite is more likely, as we observe that tonic EDA drops the most during the face-to-face interactions. This apparent contradiction suggests that in this experiment, the sympathetic stress response (which is initially high, as indicated by the phasic peak during the first 5 minutes) is not further related to the participant's perception of the social interaction. This fits with previous research showing that objective measures of stress have low or no correlation with subjective perceptions of stress (Dieleman et al., 2010; Dieleman et al., 2015; Evans et al., 2013; Karkow et al., 2004; Oldehinkel et al., 2011). The finding that tonic EDA drops significantly more in face-to-face interactions may be additionally relevant for understanding telephobia (i.e. the fear of mediated interactions) (Marshall, 1995) or mediated psychotherapy (Bee et al., 2008). If mediated interactions prevent the sympathetic nervous system from relaxing it would constitute an argument against mediated psychotherapy and partially explain why some people experience anxiety when making phone-calls.

As with any behavioral experiment, methodological constraints impose limitations on the interpretation and generalizability of the results. Arguably the most substantial limitation of the current design is that it does not allow us to disentangle whether the observed physiological responses are caused by the interaction between two participants, or by the task they perform.

From Figures 3-5 we can deduce that HRV, phasic EDA, and tonic EDA do change during the time span of the experiment, and that these changes do not differ statistically between the gossip and the creativity task. However, it is still possible that it is the mere fact of interacting that is responsible for eliciting physiological changes, and that this response to the interaction overrides any task-specific effects.

To find out whether the gossip or creativity task in our study elicited a specific physiological response, irrespective of other aspects of an interaction, it would be necessary to compare the physiological measurements in the same tasks conducted alone. Such studies would need to employ a wider definition of gossip, one which would classify consumption of gossip-related media as “gossip.” In this study we operate under an assumption that gossiping is an action that requires at least two agents to be present (Foster, 2004). While the current study shows no evidence that gossiping about celebrities affects physiology differently from an interaction in which people talk about creative uses of common household items, it would be an interesting endeavor to investigate how the physiological response differs when people are engaged in interpersonal gossip (i.e., the act of gossiping) compared to when they are solitarily reading gossip (i.e. consuming gossip content which does not entail the act of gossiping) in (for example) tabloids. If the latter elicits a physiological response that is more similar to interpersonal gossip than, let’s say reading about creative ideas, this would suggest that the mere content of gossip could already prime the body for interacting with others.

Other limitations pertain to the psychophysiological measurements. For the cardiovascular measures we chose to use unobtrusive Empatica wristbands that allow conversations to proceed naturally without the inconvenience of being tied to apparatus, but at the expense of accuracy. While our equipment was sufficiently sensitive to pick up physiological differences between the face-to-face and online conditions (see Figure 5), confirming the absence of a difference between the gossip and the creativity task would require replication with more precise instruments. Similarly, the enzyme immune assay techniques we used to analyze saliva samples for oxytocin do not allow us to draw any meaningful conclusions. While a recent study by Brondino et al. (2017) reported a significant increase in salivary oxytocin after gossip, we could not replicate this and found no statistically significant rise in oxytocin levels during the interaction due to large coefficients of variation. While this may have been caused by a number of factors (including undetected errors due to matrix interference not removed during extraction, (Schultheiss and Stanton, 2009) it also lends credibility to the claims that levels of oxytocin in saliva may be below the lowest limit of quantification of the available assays, or even that oxytocin might not be present in saliva at all (Horvat-Gordon et al., 2005).

Finally, we note that our choice to limit the study to female students means that the findings reported here may not be generalizable to the population at large. Compared to all female interactions, male-male interactions may be additionally impacted by participants' level of dominance, while in male-female interactions interpersonal attraction would have to be accounted for as well. A natural extension of the current study work would be to analyze these different types of social interactions in natural environments, to try to predict, for example, if two people will establish rapport on their first date, or if two co-workers will form an effective team. In sum, the results of this experiment show that social interactions between strangers have a clear effect on autonomic activity, regardless of the topic (gossip or creativity task) or circumstances of the interaction (face-to-face vs. online). HRV drops at the beginning of the interaction, phasic EDA rapidly rises for a short duration and then returns to normal, while tonic EDA steadily declines as the interaction progresses. Most importantly, we provide further evidence to support the theory that HRV is related to the capacity to engage in social interactions (Kemp et al., 2012), as it correlated with better rapport between strangers. The changes in physiology were unrelated to changes in mood. In contrast, tonic EDA, as an index for stress, does not contribute to the perceived interaction quality, yet it diminishes faster in face-to-face interactions. Celebrity gossip in this condition appears to improve the interaction quality in comparison to creativity task, but contrary to some past hypotheses (Dunbar, 2004; Waddington and Fletcher, 2005) gossip in our experiment was neither associated with a decreased sympathetic, nor an increased parasympathetic response.

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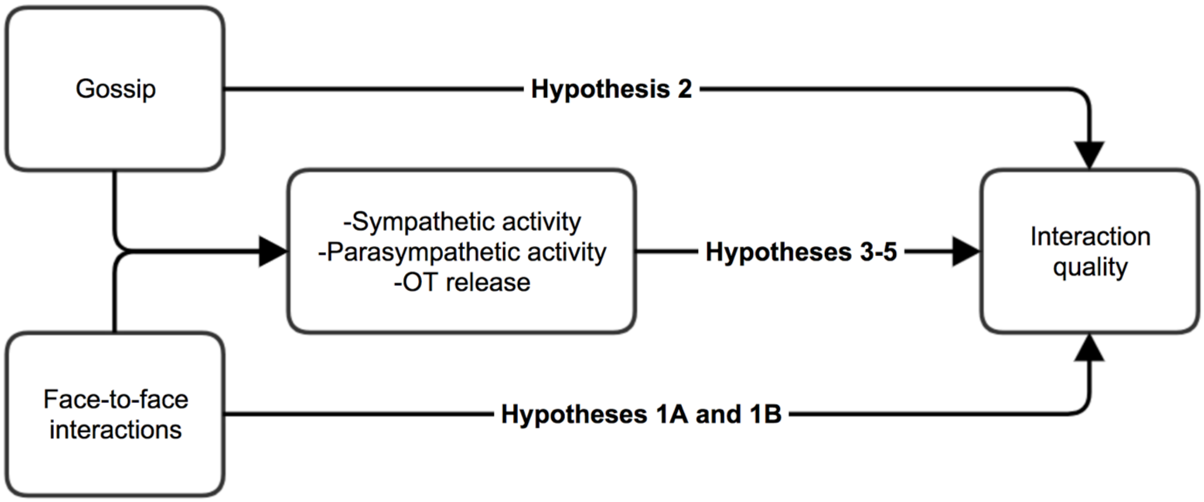

Figure 1. Model showing the influence of gossip and face-to-face interactions on interaction quality, mediated by changes in physiology.

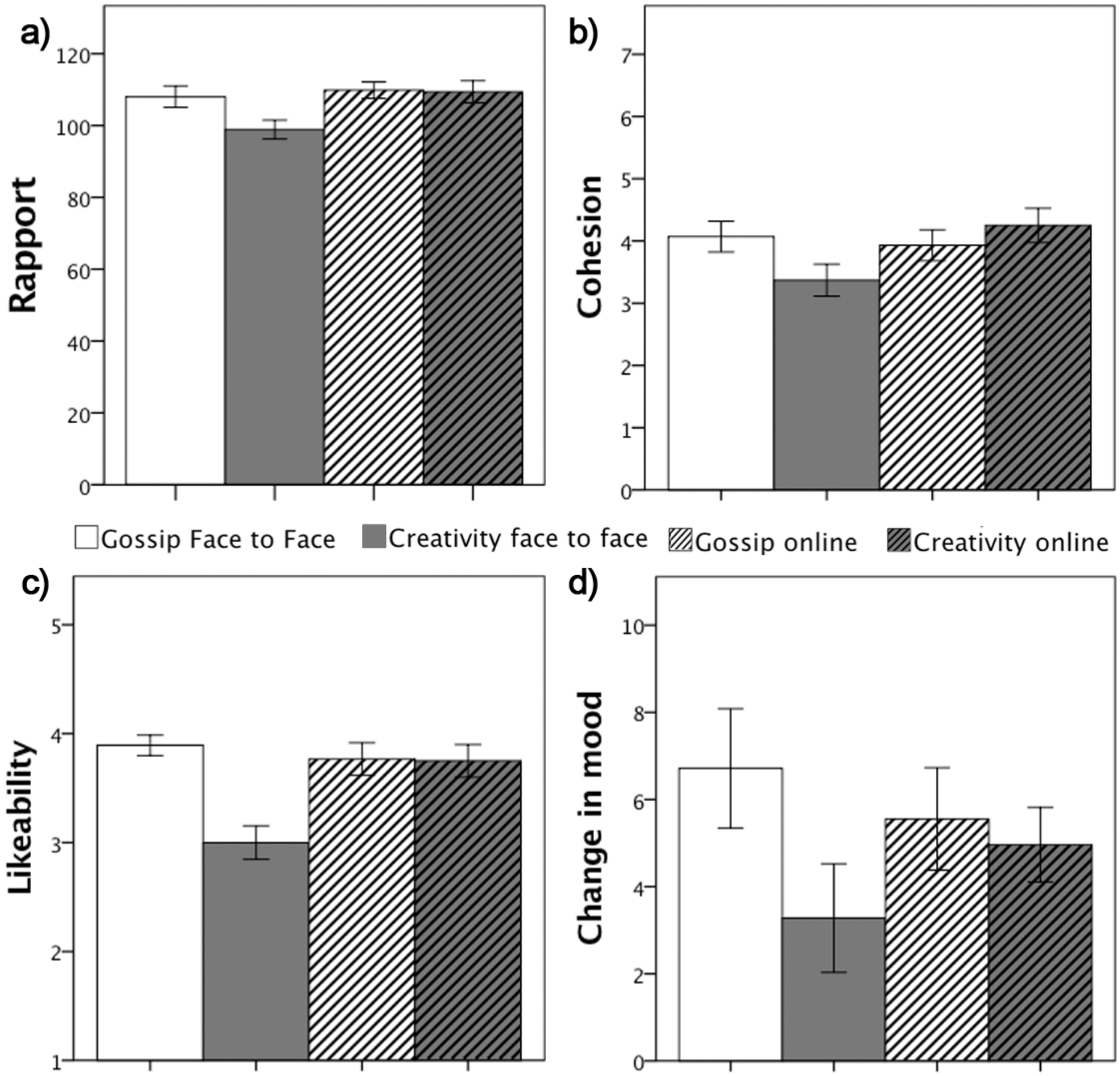

Figure 2. Mean interaction quality measures in four experimental conditions. Error bars denote +/- SE.

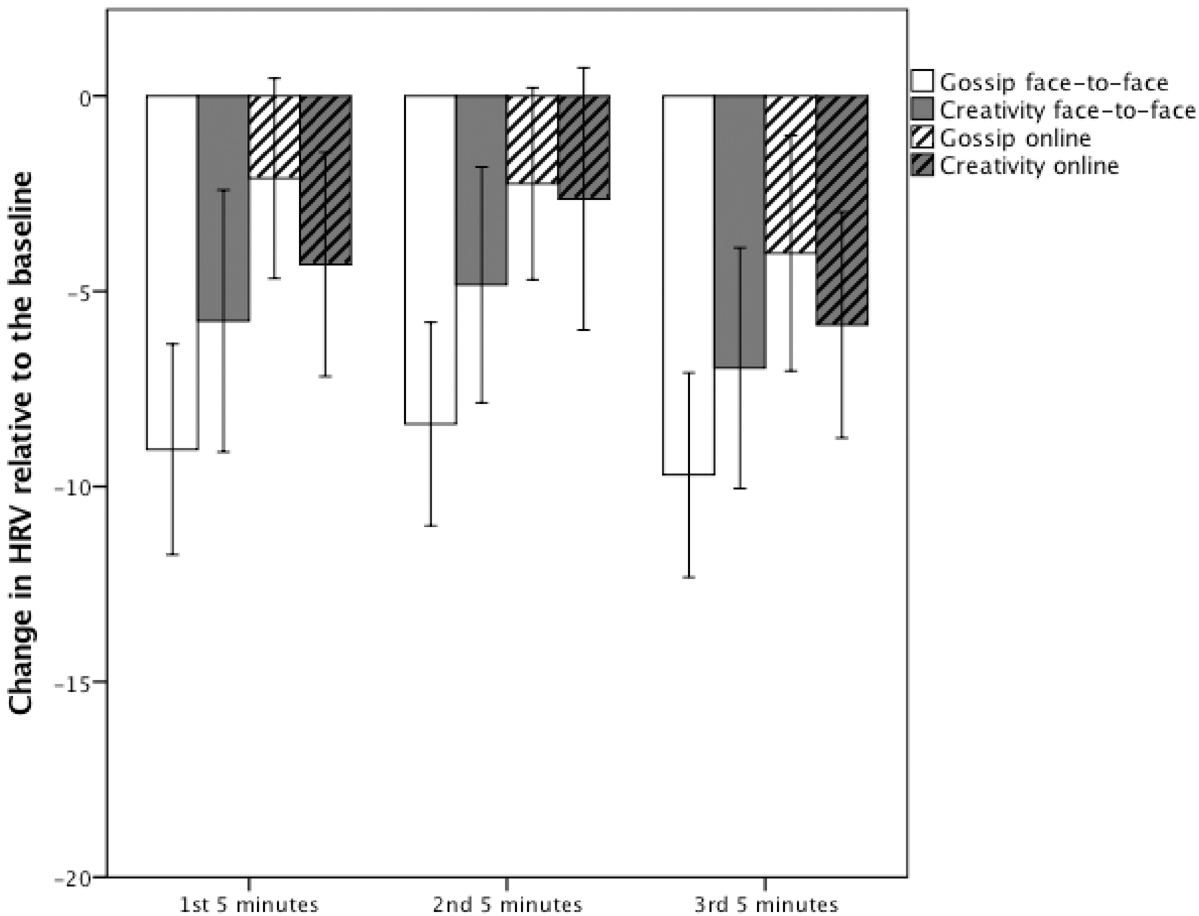

Figure 3. Changes in HRV relative to the baseline as a result of the social interaction. Error bars denote +/- SE.

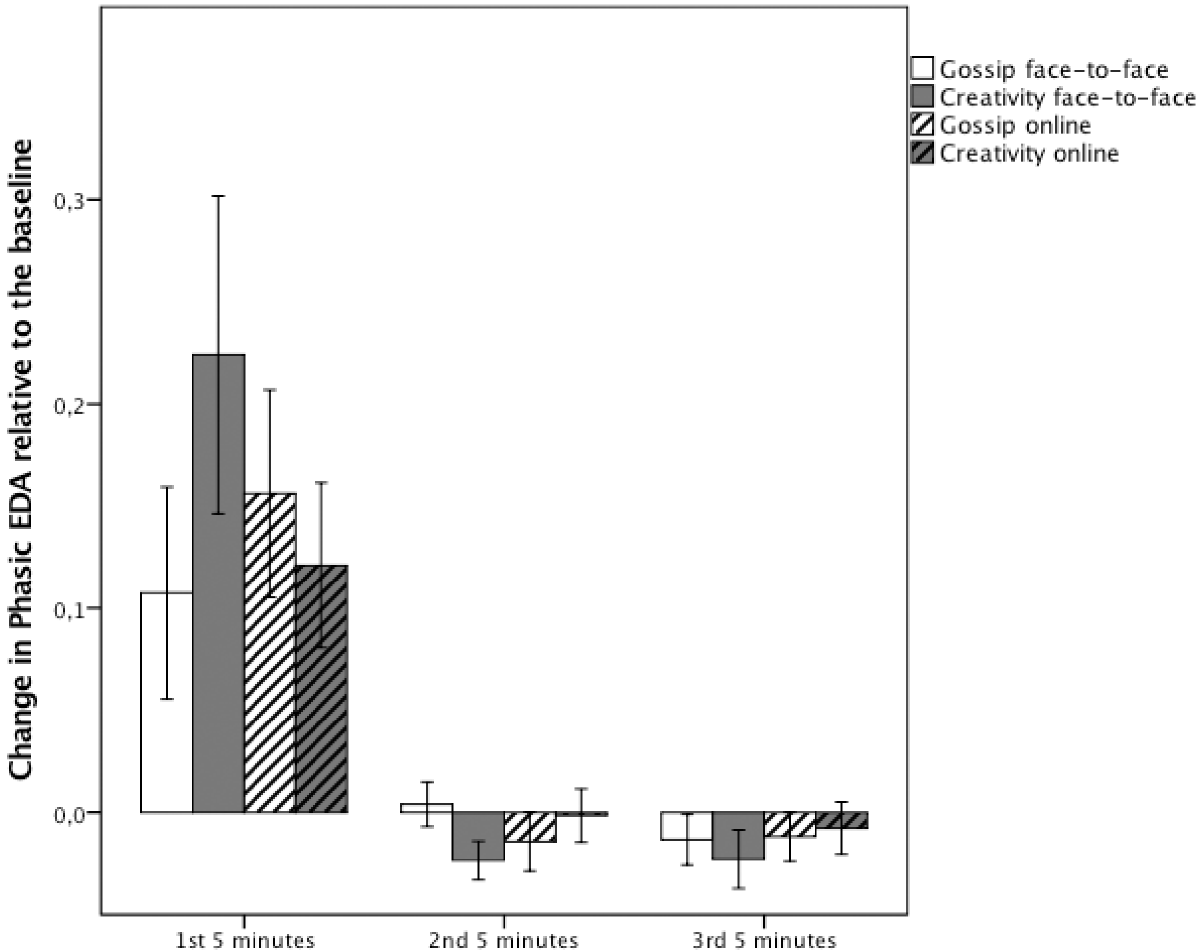

Figure 4. Changes in phasic EDA relative to the baseline as a result of the social interaction. Error bars denote +/- SE.

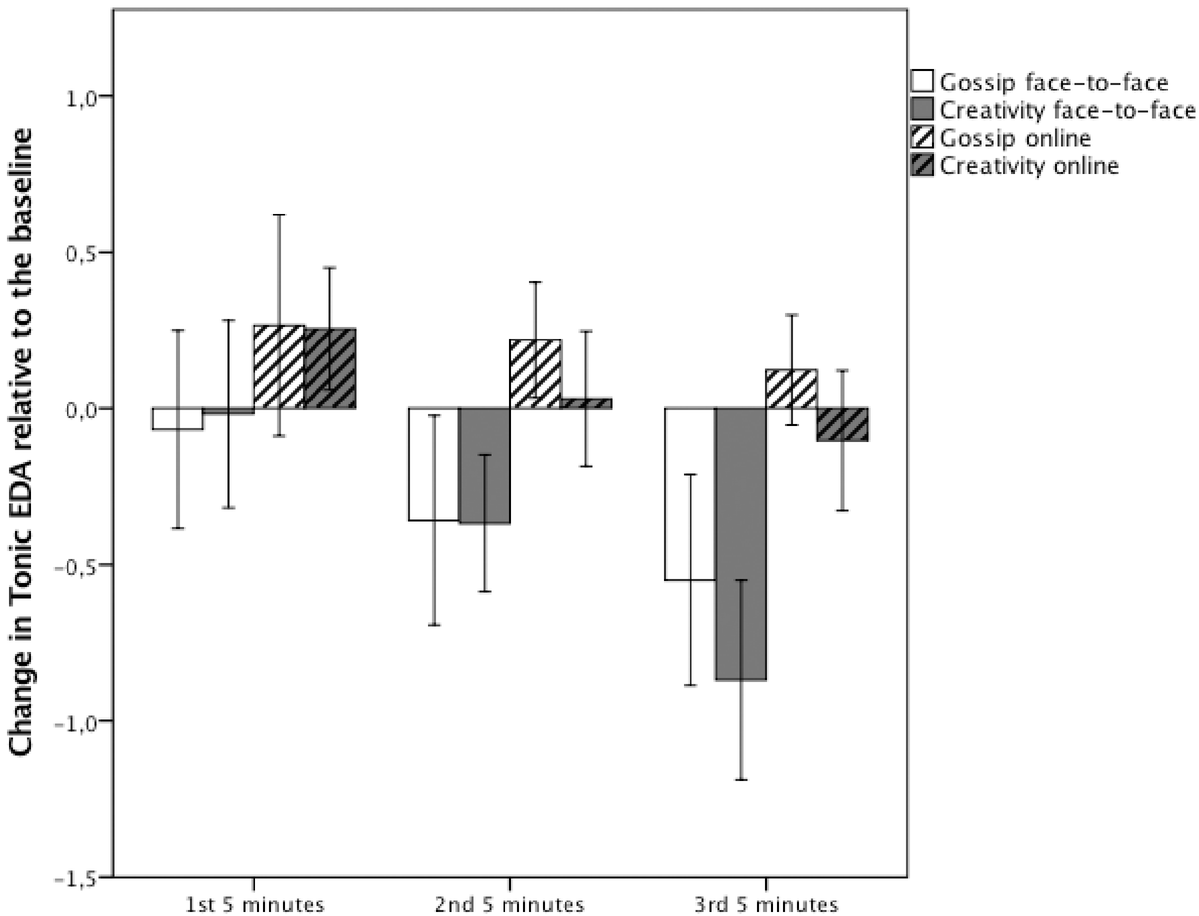

Figure 5. Changes in tonic EDA relative to the baseline as a result of the social interaction. Error bars denote +/- SE.

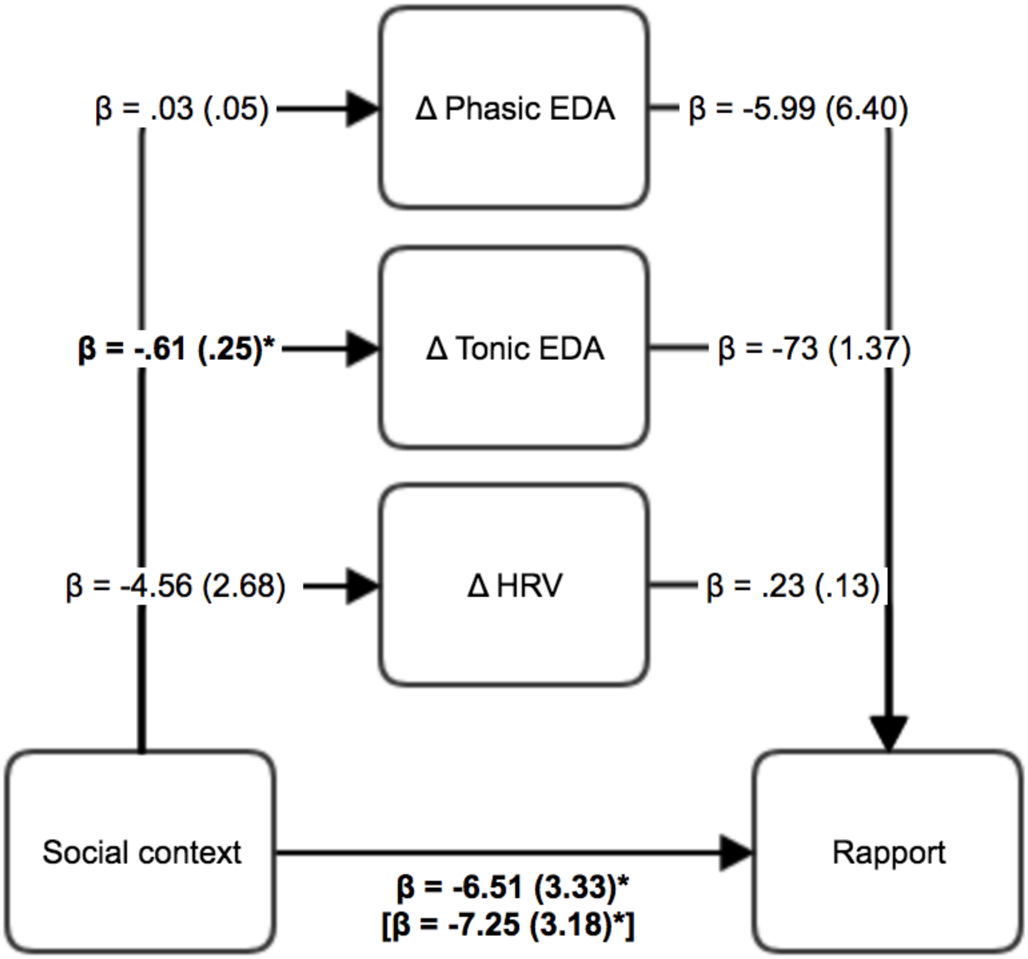

Figure 6. Mediation model of the influence of face-to-face interactions (social context) on rapport. * - p < .05, ** - p < . 01. Standard errors of the coefficients in parentheses.

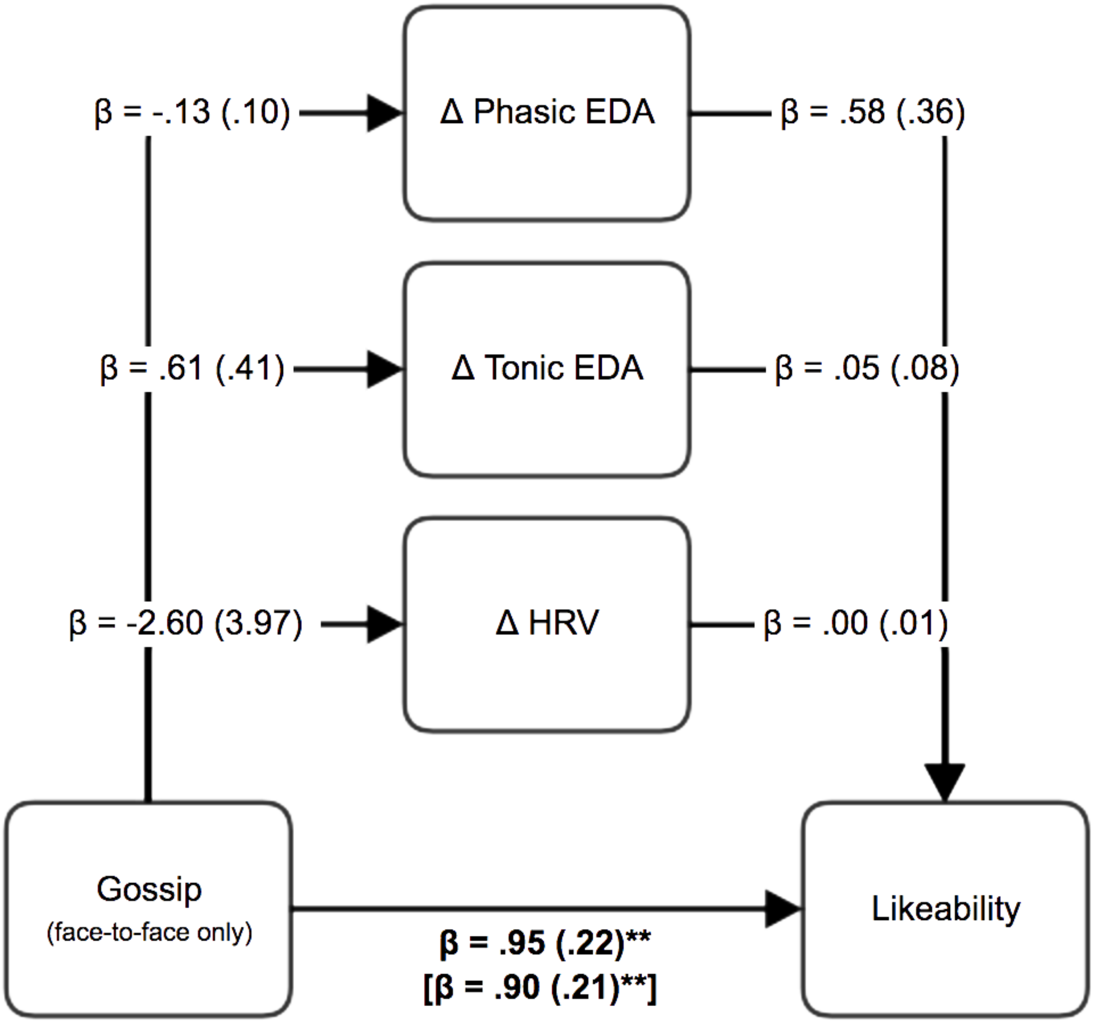

Figure 7. Mediation model of the influence of social content in face-to-face interactions on likeability. * - p < .05, ** - p < . 01. Standard errors of the coefficients in parentheses.

Table 1. Descriptive statistics.

	Mean ± SD			
	Face-To-Face		Online	
	Gossip	Creativity	Gossip	Creativity
Rapport	106.52±16.02	99.04±13.71	109.73±13.72	109.58±16.84
Cohesion	4.07±1.30	3.37±1.33	3.93±1.33	4.25±1.46
Likeability	3.89±0.9	3.0±0.15	3.77±0.15	3.75±0.15
Change in mood	6.64±7.58	3.3±6.59	5.48±6.00	4.96±4.36
HRV Baseline	56.80±2.90	52.26±3.16	49.78±2.35	54.94±3.49
HRV Interaction (Total)	48.80±1.38	45.30±2.09	48.69±1.32	49.10±2.43
Tonic EDA Baseline (µS)	1.14±0.34	1.31±0.43	1.76±0.50	0.56±0.17
Tonic EDA (3rd 5 min.) (µS)	0.81±0.17	0.51±0.16	1.93±0.46	0.57±0.13
Phasic EDA Baseline (µS)	0.05±0.01	0.06±0.01	0.09±0.02	0.04±0.01
Phasic EDA (1st 5 min.) (µS)	0.12±0.03	0.31±0.09	0.26±0.04	0.16±0.04
Oxytocin Baseline (pg/ml)	36.48±8.38	41.18±4.61	25.79±3.87	45.38±6.51
Oxytocin After (pg/ml)	29.86±5.26	48.93±6.35	37.38±4.88	47.16±7.87

The measures of interaction quality (rapport, cohesion, likeability, mood) are unitless scalar values.

Table 2. Correlation coefficients between the study variables

	1	2	3	4	5	6	7	8
1. Δ Interaction HRV	-							
2. Δ Phasic EDA (1st 5 min.)	-.14	-						
3. Δ Tonic EDA (3rd 5 min.)	-.06	.14	-					
4. Δ OT	.22*	.06	.07	-				
5. Rapport	.24*	-.10	-.00	.03	-			
6. Cohesion	.06	.29	.02	.07	.34**	-		
7. Likeability	.20*	.08	.10	.08	.60**	.40**	-	
8. Δ Mood	.05	-.17	-.14	-.08	.40**	.31**	.44**	-

Correlations for rapport, cohesion, likeability and change in mood are Spearman ρ, correlations between physiological variables are Pearson r. *$p < .05$, **$p < .01$

Table 3. Linear regression of the effects of experimental manipulations on interaction quality.

	1st Model (Main effects)			
	Rapport	Cohesion	Likeability	Δ Mood
Content	4.73 (2.79)	.18 (.24)	.45 (.16)	2.03 (1.10)
S. Context	-6.09 (2.78)*	-.36 (.24)	-.30 (.16)	-.22 (1.09)
Wald chi^2	9.13*	3.11	9.11*	3.42
N	114 (57 clusters)	112 (56 clusters)	114 (57 clusters)	109 (55 clusters)
	2nd Model (Interaction effects)			
	Rapport	Cohesion	Likeability	Δ Mood
Content	.47 (3.73)	-.32 (.36)	.02 (.24)	.59 (1.17)
S. Context	-10.5 (4.29)*	-.88 (.36)*	-.75 (.24)**	-1.68 (1.36)
Content x Context	8.67 (5.48)	1.02 (.47)*	.88 (.31)**	2.84 (2.15)
Wald chi^2	10.41*	8.17*	22.69**	3.94
N	114 (57 clusters)	112 (56 clusters)	114 (57 clusters)	109 (55 clusters)

*p< .05, **p< .01. Sample size varies between the models due to missing data in dependent variables (participants leaving out unanswered items in the questionnaires).

Table 4. Repeated measures ANOVA results of the effect of time on physiological measures.

Effect	Measure	df	Error df	F	p	η_p^2
Time	HRV	2.73	234.52	8.00	.00**	.09
	Phasic EDA	1.45	186.91	29.19	.00**	.25
	Tonic EDA	2.17	95.47	5.13	.00**	.06

*p< .05, **p< .01