Interpersonal consequences of diminished emotional expressiveness in schizophrenia: An investigation of facial expressions within face-to-face interactions

Dissertation zur Erlangung des Doktorgrades der Naturwissenschaften

an der Universität Hamburg
Fakultät für Psychologie und Bewegungswissenschaften
Institut für Psychologie

Vorgelegt von
Marcel Riehle

aus
Dortmund

Hamburg, 2016

<u>Tag der Disputation:</u> 30.08.2016 in Hamburg

<u>Prüfungskommission:</u>

Vorsitzende	Prof. Dr. rer. nat. Yvonne Nestoriuc
Erstgutachterin	Prof. Dr. rer. nat. Tania M. Lincoln
Zweitgutachter	Prof. Dr. phil. Steffen Moritz
1. Disputationsgutachter	Prof. Dr. rer. nat. Ulf Liszkowski
2. Dipsutationsgutachterin	Prof. Dr. phil. Juliane Degner

Danksagung

Diese Dissertation wäre nicht möglich gewesen, ohne die Unterstützung der fantastischen Menschen, die mich auf diesem Weg begleitet haben und mein Dank gilt ihnen allen!

Zuerst möchte ich mich bei Prof. Tania Lincoln für die herausragende Betreuung dieser Dissertation bedanken. Meine Motivation, die Herausforderungen und Tücken eines weitgehend unerschlossenen Forschungsfelds zu meistern, fußte maßgeblich auf der Hingabe und den Mut mit denen sie Forschung lebt. Tausend Dank! Ich möchte mich auch bedanken bei Prof. Steffen Moritz für die weitere Betreuung und Begutachtung dieser Dissertation.

Mein weiterer Dank gilt dem gesamten Team des Arbeitsbereichs der klinischen Psychologie! Eure kritischen und stets konstruktiven Rückmeldungen halfen mir, den Wald vor lauter Bäumen nicht aus dem Blick zu verlieren. Ganz besonders hervorheben möchte ich Dr. Jürgen Kempkensteffen, dessen unermüdliche Kritik mich an vielen Abzweigungen auf den richtigen Weg führte.

Auch danken möchte ich meiner Armee von studentischen Mitarbeiter/innen, ohne die der Arbeitsaufwand nicht zu stemmen gewesen wäre. Ein großes Dankeschön geht an Mathias, Olga, Tobias, Rukiye, Clara, Maike, Katrin, Beatrice und Hanne. Auch allen Studienteilnehmer/innen sei an dieser Stelle mein herzlichster Dank ausgerichtet.

Zuletzt möchte ich mich bedanken bei meiner Familie! Meinem Bruder danke ich für die Rivalität. Du weißt, ohne Dich hätte ich keine Ellbogen. Mein größter Dank gebührt meinen Eltern, die mich immer auf meinem Weg unterstützt haben, egal, auf welche Idee ich auch immer kam meinen Berufsabschluss und mein Leben noch komplizierter zu gestalten. Ich kann euch nicht genug danken, für das, was ihr mir trotz aller Widrigkeiten ermöglicht und dafür, wie ihr mir in schwierigen Zeiten beigestanden habt. Dies ist für euch.

Table of contents

List of Figures

List of Tables

Interpersonal consequences of diminished emotional expressiveness in schizophrenia: An investigation of facial expressions within face-to-face interactions

Background: This dissertation aimed at identifying possible behavioral mechanisms that contribute to the social isolation of people with schizophrenia apart from stigmatization and social withdrawal. People with schizophrenia have been consistently found to show diminished affiliative behavior, particularly concerning positive facial expressions. This thesis therefore investigated facial expressiveness and facial mimicry of people with and without schizophrenia to test whether diminished affiliative facial expressiveness associated with schizophrenia leads to rejection by interaction partners.

Method: Facial expressions were captured via electromyography (EMG) at two muscle sites (Zygomaticus Major for smiling, Corrugator Supercilii for frowning) throughout dyadic face-to-face interactions. A novel method for the quantification of emotional facial mimicry in face-to-face interactions was developed and validated. EMG estimates of smiling, mimicry of smiles, and frowning exhibited by participants were used to predict the social evaluation of the interaction partner after a face-to-face interaction. The influence of facial affect recognition on emotional facial mimicry was additionally tested

Results: Emotional facial mimicry could be reliably quantified for the Zygomaticus (smiling) but not for the Corrugator (frowning). In people with schizophrenia, smiling behavior explained about 71% of the variance in the interaction partner's social evaluation after the interactions. In patients, the relationship with smiling behavior was less pronounced and non-significant, while expressive negative symptoms were a good predictor. Facial affect recognition, predicted mimicry of smiles only in healthy controls.

Conclusion: People with schizophrenia suffer from an empathic deficit that leads to social rejection by their interaction partners. Diminished smiling behavior in affiliative interactions is a viable proxy for this empathic deficit, which likely stretches to other nonverbal channels as well.

Chapter 1: Thesis introduction & theoretical background

Humans are ultra-social animals. Social communication thus is one of the most important parts of human life. Our species has developed the ability to read social-communicative signals from fellow human beings almost automatically. For example, emotional facial expressions can be processed in the hint of an eye (i.e. subliminally) and evoke corresponding facial expressive responses. From an evolutionary perspective, being able to read social cues at such a remarkable level helps us navigating through the complex social structure human life entails. Our social environment then is one of the most rewarding and supportive resources to help us deal with daily hassles and life in general. However, when social cue processing and social communication go awry, the social environment can very readily become an unrewarding or even hostile place. Oftentimes, the social environments of people with a diagnosis of schizophrenia are such unrewarding, hostile places, which is a rich source of distress for the affected people. It is for this reason that thoroughly investigating the mechanisms that underlie the social adversities associated with schizophrenia has to be a primary aim for researchers in the field. Once understood, this deliberating aspect of schizophrenia may be effectively targeted in psychotherapeutically oriented interventions. This dissertation addresses one aspect of social communication in schizophrenia, facial expressiveness, and will attempt to contribute to the understanding of aberrant social interactional behavior of people with schizophrenia.

In the following six sections, the theoretical basis for this dissertation will be introduced that will lead to the research questions and general hypotheses for this dissertation (chapter 2). In section 1.1 a description of the symptomatology of schizophrenia will be given with special emphasis on the negative symptoms of the disorder. Section 1.2 will provide an overview on what is the current state of knowledge on social network structures in schizophrenia and will identify aberrant social behavior and negative symptoms as an important contributor to social isolation in schizophrenia. In section 1.3, studies that have investigated aberrant social behavior in schizophrenia will be addressed and will conclude with identifying a poor ability to create rapport in schizophrenia as a potential social consequence of aberrant social behavior. Section 1.4 then will focus on the social psychological background of the concept of rapport and provide a working definition for the assessment of nonverbal correlates of rapport. Emotional facial mimicry will be introduced as a key interactional behavior that can foster rapport in social interactions and its social psychological backgrounds will be covered in section 1.5. Finally, in section 1.6, it will be shown how these basic psychological concepts apply to the interactional behavior schizophrenia. It will be shown that difficulties in emotional facial mimicry in schizophrenia are likely linked with social cognitive deficits and might have the potential to explain the lack of rapport in interactions with people with schizophrenia.

1.1. The positive and negative symptoms of schizophrenia

The symptomatology of schizophrenia can be roughly divided in two major symptom domains, positive and negative symptoms. These terms have been established to describe the nature of the associated symptoms: Positive symptoms (e.g. delusions and hallucinations) are experiences that represent elevations of normal experiencing. Negative symptoms on the other side represent demotions with regard to normal experiencing (e.g. affective flattening, amotivation for social activities). According to the DSM-5 (Diagnostic and Statistical Manual of Mental Disorders; American Psychiatric Association, 2013), a diagnosis of schizophrenia in the A-criterion requires a person to endorse at least two of the following symptoms: delusions, hallucinations, disorganized speech, severely disorganized behavior or catatonia, or negative symptoms. At least one of these symptoms has to be delusions, hallucinations, or disorganized speech and the symptoms have to be prevailing for at least one month. Roughly

0.3–0.7% of the population is affected by schizophrenia, with prevalence rates slightly ranging depending on environmental factors (McGrath, Saha, Chant, & Welham, 2008; van Os & Kapur, 2009).

The most prominent positive symptoms in schizophrenia are delusions and hallucinations. Delusions are (usually unfounded) beliefs and convictions a person holds that cause the person distress and that are being upheld even despite potentially contradicting evidence. Most common in schizophrenia are paranoid delusions (such as being persecuted or plotted against) (Freeman & Garety, 2014). Hallucinations in schizophrenia most frequently occur in the form of auditory verbal hallucinations (Mueser, Bellack, & Brady, 1990). Oftentimes people would hear voices talking (or whispering or shouting) either directly to them or about them (e.g. with other voices). Generally, experiences like these will cause emotions in the forms of anger or fear in the affected people.

In this thesis, special emphasis will be put on the negative symptoms. Negative symptoms are thought to be a major cause of distress in schizophrenia and are often described as the chronic part of the disorder. A large study has recently looked at the prevalence of negative symptoms in schizophrenia and found that about 60% of all patients endorsed at least one negative symptom (Bobes, Arango, Garcia-Garcia, & Rejas, 2010).[1] Furthermore, as will be discussed in subsequent sections, the social impairments often accompanying schizophrenia are most reliably accounted for by these symptoms. Historically, the negative symptoms have been divided in five subdomains, anhedonia, alogia, affective flattening, avolition, and attention impairment (Andreasen, 1982). However, recent research efforts have supported a two factor structure of negative symptoms, namely motivational and expressive negative symptoms (Blanchard & Cohen, 2006; Kirkpatrick, Fenton, Carpenter, & Marder, 2006; Kring, Gur, Blanchard, Horan, & Reise, 2013; Strauss, Hong, et al., 2012a).

Motivational negative symptoms are a lack of motivation to engage in possibly pleasurable activities. This may stretch out to the social, vocational, and recreational life of the patients (Horan, Kring, Gur, Reise, & Blanchard, 2011; Kirkpatrick et al., 2011). As an underlying mechanism, researchers have suggested impairments in the anticipation of the amount of pleasure one can derive from engaging in possibly pleasurable activities (Kring & Barch, 2014). The basic idea here is that because patients do not anticipate receiving *enough* pleasure from an activity, the cost-benefit-ratio computation yields the costs outweighing the benefits. The costs in this regard are the effort that needs to be spent on an activity to receive pleasure (e.g. leaving home to meet a friend to gain social exchange and support). Therefore, recent research on motivational negative symptoms has focused on effort-based decision making as well as reward learning and reward anticipation (Fervaha et al., 2013; Gold et al., 2013; Strauss et al., 2011). Roughly half of the people with schizophrenia experience motivational negative symptoms such as passive social withdrawal with at least moderate severity (Bobes et al., 2010).

Expressive negative symptoms are reductions in the expression (mainly of emotions) via nonverbal channels. The most recent conceptualization includes in the expressive negative symptoms reductions in facial expressions, gestures, prosody, and quantity of speech (Horan et al., 2011; Kirkpatrick et al., 2011). Thus, expressive negative symptoms are inherently reductions of social-communicative functions. Expressive negative symptoms such as blunted affect and verbal fluency impairments are found in roughly one third of the people with schizophrenia with at least moderate severity (Bobes et al., 2010). The nonverbal communication and facial expressiveness in schizophrenia will be discussed in more detail in subsequent sections (sections 1.3 and 1.6).

---

[1] In this study five different symptoms were assessed: Blunted affect, emotional withdrawal, poor

1.2. Social isolation in schizophrenia and the role of negative symptoms

Impairments in social functioning are a common feature of schizophrenia. Examples of the social dysfunction in schizophrenia are high rates of unemployment and low rates of affected people who get married or engage in a romantic relationship (Bobes et al., 2010).

Given the important function of social support in mental well-being (Norman et al., 2005; Norman, Windell, Manchanda, Harricharan, & Northcott, 2012), several studies have looked at how social networks are structured in schizophrenia. In this regard, people with schizophrenia have been found to have smaller and less supportive social networks than healthy controls (Buchanan, 1995; Cresswell, Kuipers, & Power, 1992; E. Macdonald, 2000). Another finding from these studies were that patients particularly had less friendships and rather comparably sized family networks (Cresswell et al., 1992; E. Macdonald, 2000). This is particularly relevant considering that sources of negative social support for people with schizophrenia often lie within the family (e.g. in terms of "high expressed emotions"; Kavanagh, 1992). Thus, in addition to the size of the network, its quality needs to be considered. In one study that looked at different qualitative aspects of the social networks of people with schizophrenia, about a third stated that they had no one to turn to when having problems. Furthermore, half of the participants stated that they did not have any comforting relationships (Bengtsson-Tops & Hansson, 2001). Another study correspondingly found that half of the participants with schizophrenia stated not having any friendships at all (Harley, Boardman, & Craig, 2012). Because these unmet social needs are a major cause for low quality of life in schizophrenia (Bengtsson-Tops & Hansson, 1999) and contribute to worse long-term outcome (Norman et al., 2005, 2012), understanding the underlying mechanisms of social isolation in schizophrenia is highly relevant.

---

rapport, social withdrawal, and verbal fluency. To qualify as present, a symptom had to be evaluated as at least "moderate".

Social isolation here is seen as an integrated concept comprising not having enough social relationships with not having relationships that provide helpful support. Internal and external factors contribute to social isolation in schizophrenia. Internally, social withdrawal tendencies will prevent the social environment from becoming involved with an individual. Social withdrawal may occur as a result of amotivation and/or anxiety. Externally, social rejection will prevent the individual from becoming involved with the social environment. Social rejection is a result of stigmatization and aberrant social behavior (cf. also Lavelle, Healey, & McCabe, 2013).

Schizophrenia is a diagnosis that is accompanied by severe stigmatization (Dickerson, Sommerville, Origoni, Ringel, & Parente, 2002). This makes it difficult to detect factors accounting for the social isolation which are not confounded by stigma in chronic patient samples. People in a first episode of psychosis and people before the onset of psychosis have also been shown to have smaller social networks which are also perceived to be less supportive (Gayer-Anderson & Morgan, 2013). In addition to this, in non-clinical populations, people that score high on social anhedonia (i.e. amotivation to engage in social activities and relationships) also report smaller and less satisfying social networks (Blanchard, Collins, Aghevli, Leung, & Cohen, 2011; Horan, Brown, & Blanchard, 2007). Several studies have pointed out that social decline (both academic and interpersonal) is likely a matter of the pre-morbid phase (Häfner, Nowotny, Löffler, an der Heiden, & Maurer, 1995; Horan, Subotnik, Snyder, & Nuechterlein, 2006; Jones et al., 1993; Strauss, Allen, et al., 2012). These findings in populations not labeled with a diagnosis are not attributable to stigma and therefore suggest that aberrant social behavior and social withdrawal may substantially contribute to the social "network crisis" (Lipton, Cohen, Fischer, & Katz, 1981) that often accompanies schizophrenia.

1.3. Social behavior in schizophrenia

As outlined in the previous section, stigma is unlikely the single driving aspect of social decline in schizophrenia and aberrant social behavior (as the second facet of social rejection) as well as social withdrawal are likely contributors. In section 1.1 it was presented that social withdrawal and aberrant social behavior are the defining features of negative symptoms. In line with these considerations, particularly negative symptoms appear to be detrimental to social network size and quality (Blanchard et al., 2011; Cresswell et al., 1992; Hamilton, Ponzoha, Cutler, & Weigel, 1989; Horan et al., 2007; Strauss, Allen, et al., 2012; Thorup et al., 2006). The social dysfunction in schizophrenia in general is also best predicted by the negative symptoms of the disorder (e.g. Blanchard, Horan, & Collins, 2005; Galderisi et al., 2014). Moreover, lower social skills have been found to relate to smaller social networks in schizophrenia and to mediate the negative impact of negative symptoms on the social support network (E. M. Macdonald, Jackson, Hayes, Baglioni, & Madden, 1998). This underlines the relevance of aberrant social behavior (which social skills are a proxy for) as a factor conducive to social isolation in schizophrenia (cf. also Penn, Kohlmaier, & Corrigan, 2000). A wealth of studies has shown that people with schizophrenia are rated less socially skilled than healthy people (e.g. Bellack, Morrison, Wixted, & Mueser, 1990) and engage in less pro-social behaviors (Brüne et al., 2008; Brüne, Abdel-Hamid, Sonntag, Lehmkämper, & Langdon, 2009; Troisi, Pasini, Bersani, Mauro, & Ciani, 1991; Troisi, Spalletta, & Pasini, 1998). Particularly, people with schizophrenia show less affiliative behavior in response to their interaction partners (Blanchard, Park, Catalano, & Bennett, 2015; Lavelle, Healey, & McCabe, 2014).

Given the lack of affiliative behavior observed in schizophrenia, it is not surprising that interactions with people schizophrenia have long been described as lacking interpersonal rapport (i.e. a feeling of connectedness with the other). For example, Rümke postulated what he called the *praecox feeling*, which would enable him to diagnose people with schizophrenia based on the lack of rapport that would be noticeable when interacting with them (Rümke, 1942). The praecox feeling in one explorative study was even put to the empirical test and predicted a diagnosis of schizophrenia fairly well (Grube, 2006). In 1987, the Positive and Negative Syndrome Scale (PANSS; Kay, Fiszbein, & Opler, 1987) was developed for the assessment of psychotic symptom severity and included in the negative scale an item labeled "Poor Rapport". The item described a lack of empathy, interest, and openness with the interviewer and directly linked this with reduced verbal and nonverbal behavior. Poor rapport assessed with the PANSS has been shown to relate to poorer social functioning and poorer therapeutic alliance, suggesting that a poor ability to create rapport has negative social consequences (Bobes et al., 2010; Riehle et al., 2015). It is important to note that these negative consequences most likely stem from the negative evaluation of an interaction with a person with schizophrenia by an interaction partner. Yet, only few studies have looked at social evaluations of people with schizophrenia by everyday interaction partners (Lavelle et al., 2013; Penn et al., 2000; Raffard et al., 2015). Those, who did, have consistently shown that aberrant social behavior in schizophrenia is related to poorer rapport. In the following section (section 1.4.), rapport will be conceptualized theoretically, since poor rapport might be an interpersonal consequence of aberrant social behavior and crucial for social rejection in schizophrenia.

1.4. A conceptualization of rapport

In a seminal paper, Tickle-Degnen and Rosenthal (1990) suggested a theoretical framework for the investigation of nonverbal behavior associated with rapport. This framework has informed several studies in the research fields of social psychology (e.g. Miles, Nind, & Macrae, 2009; Tschacher, Rees, & Ramseyer, 2014), clinical psychology (e.g.

Ramseyer & Tschacher, 2011), and schizophrenia research (e.g. Kupper, Ramseyer, Hoffmann, & Tschacher, 2015; Lavelle, 2011; Varlet et al., 2012). It will also be adopted in this thesis.

Essentially, rapport, as defined by Tickle-Degnen and Rosenthal (1990), is a positive feeling of connectedness that emerges between two interaction partners. High levels of rapport with another person are thought to motivate approach behavior in an individual towards the interaction partner, as for example to be willing to engage in more interactions with the interaction partner. Tickle-Degnen and Rosenthal posit three assessable interactional components of rapport: *mutual attentiveness*, *positivity*, and *interpersonal coordination*. Mutual attentiveness refers to the attentiveness for the interactional signals of the other person and is a prerequisite for interpersonal exchange. As behavioral correlates for this aspect of rapport, Tickle-Degnen and Rosenthal suggested body posture and orientation (e.g. oriented towards the interaction partner) or eye gaze (e.g. directed towards the interaction partner). Positivity in an interaction is expressed through behavioral signals such as smiling or head nodding. It thus refers to the presence of positive versus negative behavioral expressions in an interaction and shapes an interaction's valence. Interpersonal coordination refers to the degree the interaction partners show more or less similar behavior that is temporarily coupled. Interpersonal coordination is thought to signal that interaction partners are "in sync" (p. 286).

Tickle-Degnen and Rosenthal (1990) also presented meta-analytic data to show which of the three aspects (attentiveness, positivity, coordination) best relate to feelings of rapport. They separated interpersonal contexts into helping (e.g. interactions with physicians or psychotherapists) and non-helping (e.g. interactions with a new acquaintance or with a study interviewer) contexts. They found that in non-helping contexts measures of mutual attentiveness and positivity impacted on rapport, whereas these types of measures only had low impact on rapport in helping contexts. In both non-helping and helping contexts, interpersonal coordination showed a medium (non-helping contexts) to large (helping contexts) effect on rapport.[2] Thus, when studying clinical populations, interpersonal coordination is of particular interest, because it might relate to both helping and non-helping contexts.

Slightly different facets of interpersonal coordination are *interpersonal synchrony* (e.g. *nonverbal synchrony*; Ramseyer & Tschacher, 2011; Tschacher et al., 2014) and *behavioral mimicry* (Chartrand & Lakin, 2013). Whereas behavioral mimicry presumes that both interaction partners engage similar or even identical movements (e.g. moving the corners of the lips upwards for a smile in response to an interaction partner's smile), interactional synchrony is more concerned with the timing of movements which may or may not be similar (e.g. head nodding in response to gestures). Nevertheless, studies have usually assessed interpersonal synchrony of similar behaviors, such as head movements or gesturing (e.g. Kupper et al., 2015; Lavelle, 2011). Concurrently, the concept of behavioral mimicry includes the implicit assumption that the mirrored behaviors are more or less closely timed (Chartrand & Lakin, 2013). However, the level of observation employed in studies on behavioral mimicry has rarely accounted for the timing component so far. For example, a study representative for the field has shown that the overall amount of foot shaking exhibited by participants is elevated when a confederate interaction partner engages in this behavior more, but has not looked at whether or not the participants actually shook their feet whenever the confederate did so (Chartrand & Bargh, 1999). Given the overlap of these two constructs and their operationalizations, it is not surprising that behavioral mimicry and interactional synchrony have been shown to have similar prosocial functions and to both promote interactional rapport (Chartrand & Lakin, 2013). This suggests that both the matching of

[2] All of these relationships were positive correlations suggesting that more of a kind of behavior leads

behaviors as well as doing so closely timed promotes rapport. For this thesis, behavioral mimicry thus will be investigated with an additional emphasis on the timing component. This approach has rarely been adopted so far and a working methodology is lacking in the field. The first step in this dissertation (study 1, section 3.) therefore was the development and the validation of a method that assessed the timing of matching interactional behaviors. The selection of a circumscribed interactional behavior to investigate in this regard was based on considerations informed by both social psychology and schizophrenia research. These considerations will be outlined in the following two sections.

1.5. Behavioral and emotional mimicry

As outlined in the previous section, behavioral mimicry is a matching of motor movements and behaviors between interaction partners, which is established by one person mirroring the behaviors of another person. Various studies in the field have looked at a variety of different movements and behaviors and have overwhelmingly shown that "people virtually mimic everything they observe in others" (Chartrand & Lakin, 2013, p. 286). The neuronal basis for these observations is thought to lie within specialized brain circuitries that become active when observing the movements of another person, the mirror neuron system. That is, observing a movement performed by another person will activate similar brain regions as when actually performing the movements (Iacoboni et al., 1999). Further evidence for this "matched motor hypothesis" (Hess & Fischer, 2013) and a "perception-behavior link" (Chartrand & Bargh, 1999) comes from studies that have shown that behavioral mimicry occurs even when it is intentionally suppressed (e.g. Dimberg, Thunberg, & Grunedal, 2002). However, despite humans readily and unintentionally engaging in behavioral mimicry, the automaticity of this process is questioned by studies showing that behavioral mimicry may be

---

to more rapport.

context sensitive (Chartrand & Lakin, 2013; Hess & Fischer, 2013). For example, a priori liking of an interaction partner (Stel et al., 2010) and a higher goal to affiliate (Lakin & Chartrand, 2003) were shown to increase behavioral mimicry. In general, affiliative rather than competitive contexts have been shown to elicit elevated behavioral mimicry (Chartrand & Lakin, 2013; Hess & Fischer, 2013).

A considerable amount of the literature on behavioral mimicry stems from experimental paradigms that have looked at seemingly meaningless movements such as finger tapping (Iacoboni et al., 1999), foot shaking (Chartrand & Bargh, 1999), or face touching (Lakin & Chartrand, 2003). Some studies, however, have looked at *emotional mimicry*, the behavioral mimicry of emotional expressions of an interaction partner (e.g. Dimberg, Thunberg, & Elmehed, 2000; Dimberg et al., 2002; Stel et al., 2010). Emotional mimicry has to be considered a special case of behavioral mimicry. As noted by Hess and Fischer (2013) emotional expressions are "intrinsically meaningful" (p. 143) and thus are more context sensitive than are other behaviors often investigated in research on behavioral mimicry. For example, the positivity component of rapport (cf. section 1.4) can be conveyed by positive facial expressions (i.e. smiles). Correspondingly, most studies that have investigated emotional mimicry have looked at *emotional facial mimicry*, the mimicry of emotional facial expressions. These studies have reliably shown that participants respond with a smile upon smiling facial stimuli and with a frown upon frowning (i.e. sad or angry) facial stimuli (e.g. Dimberg et al., 2000). However, rather than merely mimicking the facial movements, participants appear to mimic the contextualized emotions that are being displayed (Hatfield, Cacioppo, & Rapson, 1994; Hess & Fischer, 2013). This requires the interpretation of the meaning of an emotional display in the given context (e.g. whether a smile is a sign of affiliation or of Schadenfreude). Studies that have shown that emotional facial mimicry is more pronounced for affiliative signals (such as smiles as opposed to frowns; e.g. Hess & Bourgeois, 2010) and for affiliative as opposed to competitive contexts (e.g. Lanzetta & Englis, 1989) support this notion. Furthermore, a recent study on the mimicry of smiling in face-to-face interactions has shown that the accurate timing of smiling mimicry appears to rely on an anticipation of the smiles of the interaction partner rather than a mere reflexive perception-behavior link (Heerey & Crossley, 2013).

Thus, whether or not emotional facial mimicry is exhibited in a face-to-face interaction appears to rely on whether an affiliative context is present and whether the emotion to-be-mimicked signals affiliation. Recognizing an emotional facial expression as an affiliative signal requires affect recognition and mental state attribution (i.e. theory of mind). People having difficulties with these social cognitive functions should therefore engage in less affiliative emotional facial mimicry, even when engaging in an affiliative interaction (such as making a new acquaintance). As will be presented in the following section, emotional facial mimicry and the social cognitive functions associated with it can be expected to be impaired in people with schizophrenia but research has been sparse in this area. Essentially, according to the conceptualization of rapport, these impairments could explain difficulties of people with schizophrenia with forming rapport with others.

1.6. Social cognition, facial expressiveness, and behavioral mimicry in schizophrenia

As outlined in the previous section, social cognitive deficits may relate to difficulties in creating rapport with another person. Social cognition in general refers to how nonverbal and verbal signals are being processed to inform the individual about the psychological state of other people in order to select appropriate behavioral responses. In social interactions, social cognition happens ‘online’, meaning that the mental state attribution one has about the counterpart is continuously updated, and by this ensures that the interaction runs smoothly (cf. section 1.5). Some social cognitive domains are markedly impaired in schizophrenia

(Green, Horan, & Lee, 2015). Recent meta-analyses have shown that people with schizophrenia particularly perform poorly in tests of affect recognition and inferring the mental state of others or theory of mind (Kohler, Walker, Martin, Healey, & Moberg, 2010; Savla, Vella, Armstrong, Penn, & Twamley, 2013). Furthermore, empathetically sharing other's emotions appears also impaired in schizophrenia (i.e. affective empathy; Bonfils, Lysaker, Minor, & Salyers, 2016). In general, people with schizophrenia appear to have difficulties when performing tasks that require reflective social processing, particularly of facial cues, and recently empathy has been suggested as a research target in this regard (Green et al., 2015). Social cognition deficits in schizophrenia are closely linked with the negative symptoms (Lincoln, Mehl, Kesting, & Rief, 2011) and might serve as mediators between neurocognition and functional outcome (Bell, Tsang, Greig, & Bryson, 2009; McGlade et al., 2008) likely via social skills difficulties (Couture, Granholm, & Fish, 2011). Moreover, in line with the concept presented in section 1.5 which suggested a direct link between the processing of emotional facial expressions and actual emotion expression, expressive negative symptoms have been directly associated with diminished facial affect recognition (Gur et al., 2006).

Given the social cognitive deficit for the processing of emotional facial expressions, are people with schizophrenia also less facially expressive than healthy people? Indeed, people with schizophrenia have been reliably shown to exhibit fewer emotional expressions than healthy controls (Kring & Elis, 2013; Kring & Moran, 2008), presumably making it „one of the most well-replicated findings in the literature on emotional responding in schizophrenia" (Kring & Elis, 2013, p. 416). Most studies in the field have focused on emotional facial expressions in response to emotion eliciting stimuli and some have looked at facial expressions in face-to-face interactions (Kring & Moran, 2008). Consistently, people with schizophrenia have been found to make less use of facial expressions than healthy controls, particularly positive facial expressions such as smiling (Blanchard, Sayers, Collins, & Bellack, 2004; Kring & Moran, 2008; Mattes, Schneider, Heimann, & Birbaumer, 1995). The reduction in emotional facial expressiveness is observable notwithstanding possible influences of antipsychotic medication side-effects (Kring & Earnst, 1999; Trémeau et al., 2005) and to some degree even in non-clinical samples (Leung, Couture, Blanchard, Lin, & Llerena, 2010; Llerena, Park, Couture, & Blanchard, 2012) and samples before the onset of psychosis (Piskulic et al., 2012; Walker, Grimes, Davis, & Smith, 1993). Reduced emotional facial expressiveness in schizophrenia thus appears to be a rather stable, trait like condition (Kring & Earnst, 1999). Furthermore, people with schizophrenia have been found to respond to positive stimuli with positive expressions and to negative stimuli with negative expressions. These appropriate responses, however, seem to be more subtle than in healthy controls (Kring & Moran, 2008), and, particularly for positive expressions, less accurately timed (Varcin, Bailey, & Henry, 2010). The latter finding emerged in one of only two studies on *emotional facial mimicry* in schizophrenia. People with schizophrenia in this study showed less activation of their smiling muscle in response to smiling facial stimuli, but only in the first 500 ms after stimulus presentation. The study extended the findings reported by Kring, Kerr, and Earnst (1999) who did not find a difference between people with schizophrenia and healthy controls in emotional facial mimciry. In line with most research on behavioral mimicry (cf. section 1.5), Kring and colleagues had not accounted for the timing component, as was done by Varcin and colleagues, possibly explaining the difference in results (this will be detailed more in chapter 5).

If people with schizophrenia have difficulties in the timing of matching interactional behavior, measures of interpersonal synchrony may also be negatively affected (cf. section 1.5). Indeed, the emerging literature on the topic suggests that interpersonal synchrony in interactions involving people with schizophrenia is disrupted. Swinging a hand-held pendulum in synchrony with another person has been shown to be impaired in schizophrenia (Raffard et al., 2015; Varlet et al., 2012) and in unaffected first-degree relatives of people with schizophrenia (Del-Monte et al., 2013). People with schizophrenia also synchronized their overall body movements with their interaction partners less than controls, which was particularly associated with the negative symptoms (Kupper et al., 2015). In addition to these findings from dyadic interactions, three-way interactions involving a person with schizophrenia were found to entail less interpersonal synchrony as assessed via head movements (Lavelle, 2011). Lavelle (2011), however, did not find an effect of the presence of a person with schizophrenia on the interpersonal synchrony in dyadic interactions. Two of these studies also assessed an association of interpersonal synchrony and rapport experienced toward people with schizophrenia and found that lower synchrony and poor rapport were indeed associated (Lavelle, 2011; Raffard et al., 2015).

The initial findings on interpersonal synchrony in schizophrenia suggest that poor rapport with people with schizophrenia may stem from a deficit in the appropriate timing of affiliative body movements. Incorporating these findings with the findings concerning emotional facial expressiveness in schizophrenia, people with schizophrenia can be expected to exhibit less emotional facial mimicry in face-to-face interactions. This, however, is still an open research question that will be addressed in this dissertation.

Chapter 2: Research questions and general hypotheses

Several open research questions will be addressed in this dissertation, with most of them addressing social processes in schizophrenia and some of them addressing social psychology in general. First, with respect to schizophrenia, only one study so far has directly compared feelings of rapport towards people with schizophrenia as evaluated by an interaction partner and in comparison to healthy controls (Lavelle et al., 2013).[3] Lavelle and colleagues (2013) did not find that interaction partners of people with schizophrenia felt less rapport with them than with healthy controls in interactions of three people. Aberrant social behavior, however, might impact dyadic interactions more directly, as the interaction partner's attentional resources are assigned to only one interaction partner and aberrant social behavior might be recognized more. Thus, the question whether people with schizophrenia are evaluated less positive by everyday conversation partners has not been addressed for dyadic interactions so far. Accordingly, whether aberrant social behavior contributes to the assumed lack of rapport with people with schizophrenia has been also only partially addressed in previous research. Furthermore, the role of emotional facial mimicry and of affiliative facial expression in schizophrenia is not yet clear, particularly not for face-to-face interactions. Finally, how negative symptoms and social cognition might affect more negative feelings of rapport with people with schizophrenia is also largely unknown. These research questions will be addressed in studies 2 and 3.

Second, so far, no study has tested whether feelings of rapport with a person are associated with the amount of emotional facial mimicry exhibited by this person in a face-to-face interaction. The postulated function of emotional facial mimicry is to signal empathy (cf. Hess & Blairy, 2001) and behavioral mimicry in general is known to relate to rapport (cf.

[3] One other study has reported on rapport differences as evaluated by interaction partners of people with schizophrenia (Raffard et al., 2015). In this study, however, the interaction was not a conversation, but consisted of swinging a hand-held pendulum (i.e. this study did not involve actual social *communication*).

sections 1.4 and 1.5). It is thus important to investigate whether different levels of emotional facial expressiveness can explain different levels of rapport with a person. This research question will also be addressed in studies 2 and 3 on aberrant social behavior associated with schizophrenia.

Third, in order to test whether emotional facial mimicry relates to levels of rapport, emotional facial mimicry has to be reliably quantified in face-to-face social interactions. Emotional facial mimicry is most reliably assessed via electromyography (EMG). However, as will be shown in section 3.1, the only study so far that has used EMG to quantify emotional facial mimicry in a face-to-face interaction (Hess & Bourgeois, 2010), used a method insensitive to the timing of the mimicry responses. Thus, a method to quantify the temporal dynamics of emotional facial mimicry has to be developed in order to address the other research questions. This research gap will be addressed first (study 1) as it is a prerequisite for studies 2 and 3.

The following general hypotheses will be tested:

1. Emotional facial mimicry can be quantified for affiliative facial expressions in dyadic face-to-face interactions by employing an analysis technique for interpersonal synchrony on continuously assessed facial movements (study 1).
2. Participants will be less motivated for future interactions with interaction partners with schizophrenia than with interaction partners without schizophrenia after a dyadic face-to-face interaction (study 3).
3. A lack of rapport felt with the interaction partner can be accounted for by a lack of affiliative facial expressiveness (smiling and mimicry of smiles) displayed by that interaction partner in a dyadic face-to-face interaction (studies 2 & 3).

4. Social cognition and negative symptoms will have a relevant impact on the amount of emotional facial mimicry expressed in dyadic face-to-face interactions (studies 2 & 3).

To test these hypotheses, two different samples were acquired. First, a non-clinical sample was used to test general hypothesis 1 in study 1 and general hypotheses 3-4 in study 2. Second, a sample of people with schizophrenia was obtained and compared to a healthy control group to test general hypotheses 2-4 in study 3.

The ethics committee of the Psychotherapeutenkammer Hamburg approved all procedures of these three studies, which were carried out in accordance with the 1964 Declaration of Helsinki and its later amendments.

Chapter 3: Study 1 – Quantifying the temporal dynamics of emotional facial mimicry in face-to-face interactions

3.1. Introduction

In sections 1.4 and 1.5, the relevance of patterns of synchronized movements in human social interaction had been described. In this regard, it was shown that humans tend to seek coordination in movement and evaluate interpersonal encounters with higher degrees of nonverbal synchrony and behavioral mimicry more favorably (Bernieri, 1988; Lakin & Chartrand, 2003; Tickle-Degnen & Rosenthal, 1990; van der Schalk et al., 2011). Thus, the quantification of synchronized nonverbal movements has become an important field of research in recent approaches to understanding the flow of human interaction in social psychology (Laroche, Berardi, & Brangier, 2014). Moreover, translating this understanding to clinical psychology is increasingly relevant, as some mental disorders, such as schizophrenia, have been linked to deficits in movement synchronization (Kupper et al., 2015; Varlet et al., 2012).

As outlined in sections 1.4 and 1.5, nonverbal synchrony, behavioral mimicry, and emotional (facial) mimicry are slightly different aspects of interpersonal coordination. Whereas research on nonverbal synchrony is primarily concerned with the *timing* of synchronized movements, behavioral and emotional mimicry are defined more by the *amount* of synchronized movements. Behavioral mimicry is thought to be context-insensitive and to rely on the mirror-neuron system, while emotional mimicry appears to additionally include a context-sensitive part, that is, the mimicry of contextualized emotions. This latter proposition relates emotional mimicry to nonverbal synchrony as both are thought to include the recognition of interpersonal context. Since interpersonal context is volatile and time-dependent, emotional mimicry may be best assessed with particular regard to the timing of the mimicry response. Emotional mimicry so far has been most extensively researched with respect to emotional facial expressions (emotional facial mimicry), but only few studies have looked at emotional mimicry in natural face-to-face interactions (Chartrand & Lakin, 2013; Hess & Fischer, 2013). As will be shown in the following, no viable research method for the quantification of emotional facial mimicry has been presented so far. This first study of this dissertation therefore sought to develop and validate a method for the assessment of emotional facial mimicry in natural face-to-face interactions. For this, an assessment method for nonverbal synchronization was adopted.

In general, researchers have repeatedly requested to include face-to-face interactions into the research on social interactions more frequently (Fischer & van Kleef, 2010; Heerey, 2015). With respect to research on facial expressions and emotional facial mimicry, this request has remained largely unanswered so far (Heerey, 2015). Almost the entire literature on emotional facial mimicry relies on the investigation of participants facial responses to emotional facial expressions presented on a computer screen (Hess & Fischer, 2013). Available approaches often use frame-by-frame observer ratings to decide on whether or not a given expression or action unit is present at a given time (e.g. Heerey & Crossley, 2013; Stel & Vonk, 2010). This procedure is both cumbersome and prone to measurement errors due to the subjective evaluation of expressions by human coders. This is why researchers recently have tried to objectify and simplify the assessment of facial expressions and emotional facial mimicry, for instance by using real-time avatars and face-tracking (Boker et al., 2009). However, face-tracking software is still advancing and prone to measurement error due to position shifts, head turns, and non-detection of minimal movements (Cohen, Morrison, & Callaway, 2013; Messinger, Mahoor, Chow, & Cohn, 2009).

Electromyography (EMG) allows for a more objective and economical assessment of facial movements, is able to produce time series data with high frequency sampling rates, and can even detect covert or subthreshold movements (Dimberg, 1982). In laboratory studies of facial mimicry it is therefore the gold-standard assessment method of facial movements. The only study to assess facial mimicry in a dyadic setting using EMG was published by Hess and Bourgeois (2010). The authors showed that smiling but not frowning was mimicked in dyadic affiliative interactions of strangers. For this, they averaged the EMG activity of a muscle site for epochs of 15 s within participants, which then were correlated across two interaction partners. This approach, though innovative, might not have been ideal, however, as research on the timing of facial mimicry responses has shown that the peak mimicry response is usually observable within 1 s after stimulus onset (Dimberg et al., 2000; Heerey & Crossley, 2013). Moreover, mimicry of genuine smiles may even occur as quickly as within 200 ms after stimulus onset indicating an *anticipated* mimicry of smiling (Heerey & Crossley, 2013). As the anticipation of smiles might be the product of (social) cognitive processes different from those involved in the reflexive mimicry response, assessing the temporal dynamics of mimicry responses as precisely as possible is crucial.

Maintaining the high temporal resolution of the EMG data therefore is important for any analysis that aims at quantifying the temporal dynamics of emotional facial mimicry in face-to-face interactions. As mentioned earlier, assessment methods that quantify nonverbal synchrony might be helpful in this regard. Windowed cross-lagged correlation (WCLC; Boker, Rotondo, Xu, & King, 2002) is a statistical analysis technique that allows for the quantification of the synchrony of two behavioral time series while largely maintaining the temporal resolution of the input data. Moreover, it accounts for the possibility that synchrony between the time series may occur with a time lag as well as simultaneously. Interpersonal synchrony assessed with WCLC has been shown to be reliably quantifiable for whole body movements (Boker et al., 2002; Ramseyer & Tschacher, 2011) and to be a significant predictor of more positive interpersonal outcomes (Ramseyer & Tschacher, 2011; Tschacher et al., 2014). However, WCLC has not yet been used to analyze EMG data or to quantify emotional facial mimicry in face-to-face interactions (one exception is a case study by Messinger et al., 2009, who used WCLC to investigate mother-infant-interactions but did not use EMG). Adapting WCLC for facial EMG data would close these research gaps and help to objectify the investigation of emotional facial mimicry in face-to-face interactions by bypassing a human coding procedure.

Therefore, in this study the suitability of WCLC to quantify the temporal dynamics of emotional facial mimicry in dyadic interactions was tested. In accordance with Hess and Bourgeois (2010), smiling muscle (Zygomaticus Major) and frowning muscle (Corrugator Supercilii) activations were analyzed within dyads of participants who talked about positive and negative life events. WCLC was validated against a control condition of chance-level synchrony and its reliability was tested over the course of an interaction by means of the consistency of the synchrony estimate produced by WCLC. As an additional indicator of construct validity, the key findings on emotional facial mimicry in face-to-face interactions mentioned above should be replicable. These include the finding by Hess and Bourgeois (2010) who found that smiles but not frowns were mimicked by interaction partners in an affiliative interaction, and the finding by Heerey and Crossley (2013) that smiling synchronizations occurred within 200 ms.

The following hypotheses were tested in study 1:

1. WCLC detects synchrony of facial muscle activity better than would be expected by chance.
2. Corrugator (frowning) activity is mimicked less than Zygomaticus (smiling) activity.
3. Emotional facial mimicry can be measured reliable over the course of an interaction.
4. Zygomaticus (smiling) mimicry occurs within time lags of ±200 ms.

3.2. Method

3.2.1. Sample

Data were collected from 33 dyadic interactions of mentally healthy subjects ($N = 66$), recruited from the community of the city of Hamburg. Inclusion criteria for all participants were age 18-65, no life time diagnosis of any mental disorder (exception: no diagnosis of alcohol/drug abuse within the past year), no self-reported history of any neurological disorders, and verbal IQ > 80. Dyads were matched with respect to sex and approximate years of education. This sample will also be analyzed with a focus on negative symptoms in study 2 (section 4). Measures relevant for study 2 will be described in detail in the methods section of study 2 (section 4.2).

As outlined earlier and as will be described in more detail in sections 3.2.3 and 3.2.4, EMG data were collected throughout the dyadic interactions. Three of the 33 dyads had to be excluded from the analyses because of missing EMG data (technical recording failure = 1 dyad) or excessively noisy EMG-data due to electrodes not properly adhering to the skin (= 2 dyads). Thus, 30 dyads ($N = 60$) were included in the analyses for study 1. Nineteen of these dyads were female/female, the remaining eleven were male/male. Mean age of participants was 35.1 years (SD = 12.2; range: 19 to 62) and mean years of education were 16.1 years (SD = 3.1; range: 10 to 22). All participants were unaware of the clinical focus of the project, uninformed about the fact that the EMG electrodes measured facial movements during the interactions, unaware of the hypotheses of this study, and indicated in the end of the experiment that they had never encountered their interaction partner before.

3.2.2. Social interaction task

For the dyadic interaction, the participants prepared a positive and a negative life event according to standardized instructions. For the positive events, participants were instructed to recollect an enjoyable event that had happened to them within the last 12 months. For the negative event, participants were instructed to recollect an event where they had felt annoyed or angry (cf. Hess & Bourgeois, 2010). The participants then rated how enjoyable/annoying this event was for them on a scale from 1 ("not at all enjoyable/annoying") to 9 ("maximally enjoyable/annoying"). Participants were instructed to try to explain to the interaction partner, why the event was enjoyable/annoying. In the instructions the terms 'conversation' and 'conversational topics' were used to refer to the interaction and to the events, respectively, to avoid passivity in participants in the listener role. Accordingly, the instructions also included a passage specifically encouraging participants to actively respond to the told stories when in listener role.

The interaction started with a 2-min warm up phase in which participants were supposed to introduce one another and discuss whether they wanted to use the formal or informal way of addressing each other in German. In fact, all participants chose to address one another using the informal way (equivalent to using the first name in English). Then participants discussed their positive and negative life events. Each event was the conversational topic for approximately 3 min, while experimenters announced topic shifts via an intercom. Event valances were blocked for the interaction so that both positive and both negative events were discussed directly after one another. The interaction ended with a cool down period of 2 min, announced as a waiting period by the experimenters. It had been intended to counterbalance the order of valence blocks across all dyads in the sample. However, due to non-adherence of some of the experimenters to the study protocol in this single aspect of the protocol, only eight out of 30 dyads actually started with the discussion of negative events.

3.2.3. Procedures

Presence of mental disorders was ruled out based on an interview session using the Structured Clinical Interview for DSM-IV Axis I (Wittchen, Fydrich, & Zaudig, 1997), a semi-structured interview assessing the diagnostic criteria of the mental disorders according to the DSM-IV. Verbal IQ was assessed with the German Multiple Choice Vocabulary Test (Lehrl, 1999), in which participants are required to select German words out of lists of pseudo-word distractors. This assessment has been shown to be particularly useful in schizophrenia research (Exner & Lincoln, 2012) and was chosen for this reason also for the non-clinical sample presented here. The assessment of exclusion criteria (psychopathology) and other questionnaires relevant to study 2 lasted for ca. 1.5 h.[4] Suitable participants were then invited to take part in a dyadic interaction on another day. As a cover story, the participants were told that the study investigated differences between interactions of close friends and strangers and that they had been assigned to the stranger-group. They were also informed that, throughout the conversations, 'psychophysiological data' would be collected from their faces by four 'sensors' and that the interactions were filmed.

On the day of the interaction, the two interaction partners arrived at separate rooms, where they gave informed written consent. When the participants had prepared their positive and negative event, they were taken to the room in which the interaction took place. In the following, the application of the EMG electrodes (cf. section 3.2.4) occurred at the same time for both participants of each dyad by two different experimenters. After visually checking signal quality, participants were instructed to knit their eyebrows as much as they could and to smile as widely as they could. The resulting activation levels were used as benchmarks for the maximum contraction of each muscle site (cf. section 3.2.5). To prevent priming participants to pay extra attention to facial movements, participants were told that the movements were necessary to check whether the electrodes would adhere to their faces when talking. After this, the experimenters left the room and the interaction task was carried out as described above. After the interaction, participants filled in several questionnaires (cf. study

[4] A full list of assessments will be provided in the methods section to study 2 in chapter 4.

2, section 4), were compensated monetarily with 10 € per hour of attendance, debriefed, thanked, and dismissed.

3.2.4. EMG measurement

Facial EMG data were collected throughout the interactions continuously from the Zygomaticus Major (smiling muscle) and the Corrugator Supercilii (frowning muscle). The assessment was restricted to these two muscle regions for several reasons: The number of muscle sites to record EMG data from was intended to be limited to a maximum of two muscle sites for two reasons. First, the invasiveness of the EMG method was intended to be kept minimal in order to increase the ecological validity of the assessment (having fewer electrodes attached to the face will more likely resemble a “natural” interaction than having more electrodes attached to the face). Second, a similar study design was also planned to be used in study 3 which involved a clinical sample with participants with a diagnosis of schizophrenia. Thus, the number of electrodes in the face was intended to be limited to a minimum also to reduce the aversiveness of the situation (talking to a stranger, being filmed, having “psychophysiological data” recorded from the face). One reason for selecting the Zygomaticus Major and Corrugator Supercilii muscle sites was that the study design of Hess and Bourgeois (2010), who investigated these two muscle sites, was adopted with respect to the interactional set up and conversational content. Furthermore, these two muscle sites are the most common in research on emotional facial mimicry (Hess & Fischer, 2013). Hess and Bourgeois (2010) investigated other potentially relevant candidates for the assessment, the Levator Labii Alaeque Nasi (associated with disgust displays) and Orbicularis Oculi (associated with smiling), but their results were best accounted for by the Zygomaticus and Corrugator assessment.

The electrodes were placed directly before the beginning of the interaction and after cleansing the skin sites using Nuprep™ abrasive gel. Ag/AgCl surface electrodes with an inner diameter of 6 mm an outer diameter of 13 mm were placed onto the skin of participants using 13 mm adhesive discs with an inner diameter of 5 mm. The electrodes were filled with TEN20™ conductive paste. Electrodes were placed in pairs (bipolar measurement) at the two muscle sites (Corrugator Supercilii and Zygomaticus Major) 13 mm apart from one another according to the guidelines by Fridlund and Cacioppo (1986). Ground electrodes were 7 mm Ag/AgCl electrodes that were placed via an ear-clip on one earlobe of each participant (cf. Tassinary, Cacioppo, & Vanman, 2007).

The EMG signal was measured in both participants simultaneously using a single NeXus-10 Mark-II (Mind Media BV, The Netherlands) device. Both participants' ground electrodes were connected to the EMG device's ground electrode input channel via a ground-splitter (Mind Media BV, The Netherlands). BioTrace software (Mind Media BV, The Netherlands) was used for monitoring, initial preprocessing, and data storage on a computer in another room which was connected to the NeXus via USB cable. The EMG data was initially sampled at 2048 Hz. The signal was down-sampled to 32 Hz using the root mean square (RMS) method, which was performed on the rectified signal and with a time constant of 1/16 s. EMG data were then exported for further analysis in MATLAB (MathWorks, MA, USA) environment.

3.2.5. Preprocessing of EMG time series data

To create a proper control condition of chance level synchrony, pseudo-interactions (cf. Ramseyer & Tschacher, 2011; Bernieri, 1988) were generated by randomly assigning the time series of participants taken from different dyads to one another (thus, these were participants who did not actually communicate with each other), cutting the longer series to match the length of the shorter one. In these pseudo-interactions all synchrony should be subject to chance and thus comparing genuine and pseudo-interactions can be used as a test of the signal-to-noise ratio.

Before running the WCLC analysis, the time series data of both genuine and pseudo-interactions were preprocessed in several steps using specifically written MATLAB scripts. First, data were cleared from artifacts by deleting all data points that exceeded the critical benchmark level obtained from participants before the interaction (cf. section 3.2.3). By this, excessive spikes in the EMG signal were deleted that occurred as artifacts due to participants touching the electrodes or significantly moving the cables. This resulted in a mean loss of 0.01% of data points per dyad. Second, the time series were normalized to a range of 0 to 1 by using min-max normalization. Third, the time series were smoothed using a moving average with a time constant of 0.5 s.[5]

3.2.6. Quantification of emotional facial mimicry

The WCLC analysis produces a parameter of the strength of the association of two time series (= synchrony) for each assessed time point of the interaction and additionally takes into account time lags between the two time series. Essentially, WCLC calculates the correlation of two time series for a series of overlapping time windows (= “a vector of sequential measurements sampled from a time series”; Boker et al., 2002, p. 341) of a constant size. The time window is “moved” along the time line in pre-specified increments[6] to obtain the correlation of the two time series at each time point. Thus, the moving of the window resembles the procedure of a moving average, with WCLC producing correlations of the two time series’ windows. Therefore, a WCLC analysis with a window size of 1 s maintains the same temporal resolution of the input data as a moving average with a time constant of 1 s. Additionally, before moving the time window an increment further in the analysis, pre-specified time lags are subsequently applied to each of the time windows and a correlation for each resulting window combination is calculated (cf. Boker et al., 2002, pp.

[5] By setting the time constant of the moving average to a value of 0.5 s, the approach taken by Ramseyer and Tschacher (2011) was approximated.

[6] For an optimal temporal resolution of the WCLC output, this increment should be set equal to the time interval between single observations in the time series (e.g. 0.1 s when the data was sampled at 10 Hz).

343-344). By shifting the time series back and forth in this manner, the WCLC analysis is able to identify the amount of synchrony at each given time point, and the time lag with which one of the two time series was *leading* the other time series at this time point. That is, person A is *leading* person B when a muscle contraction of person A is followed by a muscle contraction of person B, thus, when person B is mimicking person A. In this case, person B is said to be *pacing* person A.

The WCLC analysis was run for both genuine and pseudo-interactions using a time window size of 7 s (= 224 observations), which was moved over the time series in increments of 1/32 s (= 1 observation). The maximum time lag was 2 s (= 64 observations), which was applied in increments of 1/32 s (= 1 observation). Window size and time lag in the analysis have to be chosen due to theoretical considerations. For example, the choice of a window size may depend on how long the behavioral units to be analyzed for synchrony are assumed to be. [7] The maximum time lag should mark the maximum delay with which a synchronization response may occur, in order to be considered as a synchronization response and not as a distinct behavioral action. Here, it was expected that facial expression synchronizations would generally have durations shorter than 5 s (cf. Boker et al., 2002) and that these synchronizations would generally occur within time lags of 1 s (cf. section 3.1). In order to also capture slightly longer or more delayed responses the values were set slightly higher than what the actual expectations implied.

The correlation coefficients in the resulting WCLC matrices were Fisher z-transformed, as recommended by Ramseyer and Tschacher (2011). Matrices were then cleared of all correlation coefficients not exceeding a dyad-specific significance threshold. The threshold was derived by correcting an initial α-level of $p = .01$ for the number of correlation coefficients stored in a dyad's WCLC result matrix using Bonferroni correction.

Because the time series varied in length for each interactional phase, the WCLC matrices also varied in number of stored correlation coefficients. Therefore, the Bonferroni corrected significance thresholds were calculated individually for each interactional phase (cf. Appendix C for more information on the significance threshold employed). In contrast to Ramseyer and Tschacher (2011), who used absolute values of correlation coefficients, here, the WCLC matrices were cleared of all negative correlation values. This solution was chosen because negative correlations mark asynchrony of the two time series. This asynchrony would potentially mark what is known as counter-mimicry, which was not expected to be present in the affiliative interactions, since counter-mimicry is known to occur in competitive situations (Lanzetta & Englis, 1989). Furthermore, asynchrony may represent an artifact of the analysis. For example, a negative correlation value could represent a scenario in which *person A* started smiling as a response to *person B* stopping smiling. However, if the smiling onsets of both participants lay within 2 s of one another, this would indicate a lagged smiling synchronization. If not, the two smiles would be considered being distinct actions. Both cases are already accounted for by analyzing the positive correlation coefficients. In such cases, the negative correlation coefficients are redundant. This characteristic of the WCLC analysis is illustrated in Figure 1. It shows that high positive synchrony coefficients may be commonly accompanied by high negative (a)synchrony coefficients somewhere along the coefficient distribution of the same time window. In the figure, this parameter distribution is shown to be a cross-lagged correlation (CLC), which represents the synchrony within a specified time window (in other words: a cross section of a single time window of the WCLC analysis). Almost perfect synchrony (CLC = .99) as well as asynchrony (CLC = -.95)[8] can be observed within a single time window. However, *either* the high positive *or* the high negative

[7] Practical considerations may also play a role in the analysis. For example, choosing smaller window sizes as well as choosing larger maximum time lags increases the number of correlations calculated by WCLC and thus processing time and family wise error rate.

[8] These values are pearson correlation coefficients which are not yet Fisher z-transformed.

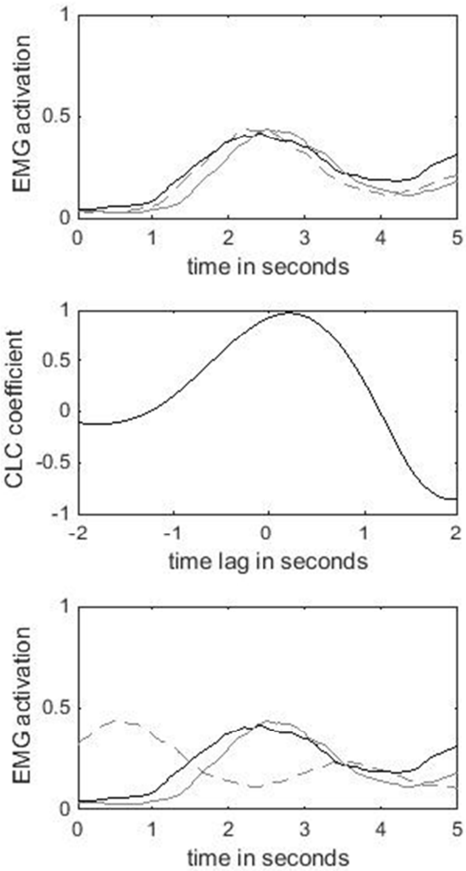


Figure 1. Cross-lagged correlation (CLC) distribution (middle panel) and the corresponding range corrected EMG time series window (top & bottom panel) of person A (black line) and person B (grey lines). The dashed line in the top panel illustrates person B's time series shifted according to the time lag corresponding to the maximum CLC (maximum synchrony) value (at +0.25 s). The dashed line in the bottom panel illustrates person B's time series shifted according to the time lag corresponding to the minimum CLC (maximum asynchrony) value (at +2.00 s).

correlation best represents the relationship between persons A and B, but not both do. Omitting negative values therefore would increase the signal-to-noise ratio and the power to discriminate between leading and pacing roles in the interaction. Nevertheless, all analyses were additionally performed on the WCLC matrices when only considering significant negative correlation coefficients. If the theoretical considerations concerning negative correlation coefficients are correct, there would be no difference between genuine and pseudo-interactions with respect to asynchrony. The main analysis assessing the difference between genuine and pseudo synchrony were repeated without the constraints of a significance threshold and the omitting of negative correlation values (thus equaling Ramseyer & Tschacher's approach) and these results are reported in Appendix C.

In all dyads, the person who was first asked to begin the conversation was defined as person 1 and the other person as person 2. Thus, in all WCLC result matrices, coefficients at positive time lags referred to person 1 leading the interaction and coefficients at negative time lags referred to person 2 leading the interaction. For the analyses of study 1, it was not necessary to differentiate between leading and pacing of persons 1 and 2 within a dyad. This differentiation is, however, used in study 2 (section 4) and will be discussed there. The WCLC analyses were calculated separately for each muscle site and for each interactional phase (warm up, positive event of person 1 [positive 1], positive event of person 2 [positive 2], negative event of person 1 [negative 1], negative event of person 2 [negative 2], and cool down).

To obtain a single parameter of synchrony for each of the six interactional phases, the grand mean of all coefficients in the respective WCLC matrix was calculated. The average of the six resulting mean synchrony levels was used as a parameter of the overall synchrony across an interaction. Additionally, it was determined for each row (= each time window) of each WCLC matrix the time lag corresponding to the peak synchrony (WCLC peaks).[9] By this, the amount of WCLC peaks that occurred at each time lag could be counted. This number was then expressed as number of WCLC peaks within a 3 minute period (= anticipated length of an interactional phase) to be able to compare the values between dyads. WCLC peaks were determined individually for each interactional phase and then summed up

[9] In cross-lagged correlation analyses (cave: not *windowed* cross-lagged correlation), the time lag corresponding to the peak value is a commonly used outcome to determine the time lag of the association of two analyzed time series (cf. Boker et al., 2002). Because in WCLC each row (= each time window) represents a single cross-lagged correlation, our peak counting approach is analogous to the established approach.

for each time lag over the six interactional phases. In this way it was possible to explore the temporal dynamics of the synchronization more closely since the number of WCLC peaks represents a better estimation of the frequency of synchronizations at a given time lag than the mean of the WCLC amplitude at this given time lag. This is because the WCLC coefficients within a single time window, across time lags, are usually substantially autocorrelated. The WCLC peaks were averaged for several segments of adjacent time lags. A segment width of ±6 observations around time lag 0 (overall segment width = 13 observations ≈ 406 ms or ±203 ms) was chosen for the inner segment. Comparing the peaks occurring in this segment between genuine and pseudo-interactions tests hypothesis 4 which stated that significant smiling synchrony would be present within time lags of ±200 ms. All other segments were then designed to have the same size. Thus, the WCLC peaks of four more segments of 13 observations (≈ 406 ms) in both the positive and negative time lag direction (overall 9 segments covering ± 1828 ms around time lag 0) were averaged.

3.2.7. Data analysis

A benchmark check was conducted on the benchmark non-normalized amplitude levels obtained for each muscle before the interaction in order to assure that the EMG set-up produced valid EMG data with respect to signal amplitudes. This was done since the assessment of facial mimicry usually assesses very subtle muscle movements that are mostly below the threshold at which muscle contractions become visible in the face. For example, Hess and Bourgeois (2010) used a threshold of 15 µV for visible vs. non-visible muscle movements. The changes in muscle activation usually reported in facial mimicry research are only several µV (e.g. ±3 µV in Dimberg et al., 2000). However, in the natural face-to-face interactions analyzed in this dissertation, more pronounced smiling and frowning behaviors were expected. For instance, Epstein (1990) reported mean benchmark Zygomaticus amplitudes of approximately 140 µV RMS and Corrugator amplitudes of approximately 80 μV RMS. The benchmark contractions across the whole sample were expected to result in μV RMS amplitudes comparable to those values. Additionally, in this dissertation, for the first time, facial EMG was collected from two people simultaneously with only one assessment device. In order to rule out that connecting two participants within a dyad to the same device systematically distorted the EMG amplitudes, the benchmark amplitudes were correlated within the two dyad-members. Non-significant correlations were expected in this regard.

To test hypotheses 1 and 2, a three-way repeated measures ANOVA was calculated (muscle site [Zygomaticus vs. Corrugator] by interaction type [genuine vs. pseudo-interaction] by (interactional) phase [warm up vs. positive 1 vs. positive 2 vs. negative 1 vs. negative 2 vs. cool down]) on the WCLC synchrony. Following hypotheses 1 and 2, a muscle site by interaction type interaction (with smiling but not frowning being superior to chance level synchrony) was expected to emerge. To follow up significant interactions, repeated measures ANOVAs or paired-samples t-tests were planned, depending on the exact type of comparison. There was no explicit hypothesis about possible differences between positive and negative narratives (the study by Hess & Bourgeois, 2010 was inconclusive in this regard). Thus, possible differences will be looked at in explorative analyses.

To test the reliability of the synchrony analyzed with WCLC over the course of the interaction (hypothesis 3), the internal consistency (Cronbach's α) was calculated across the six experimental phases for smiling and frowning synchrony, respectively, and for both genuine and pseudo-interactions. Values higher than .75 represented sufficient reliability.

Hypothesis 4 stated that smiling synchrony would be present within time lags of ±200 ms. To test this, a paired samples t-test tested for the difference between genuine and pseudo-interactions in the sum of WCLC peaks that fell within the inner segment of ±203 ms around time lag 0. In order to confirm hypothesis 4, this segment should contain more WCLC peaks than expected by chance. Additionally, difference in the number of WCLC peaks between genuine and pseudo-interactions within the other segments were explored. For all analyses, an α-level of $p = .05$ was set as the significance threshold that was corrected for family wise error rates using Bonferroni correction where needed. Medium to large effect sizes could be detected with a power of 80% in this study.

3.3. Results

3.3.1. EMG benchmark checks

The mean µV RMS benchmark amplitudes for Zygomaticus and Corrugator were M = 147.0 (SD = 73.0) and M = 153.2 (SD = 72.5), respectively. Thus, the sensitivity of the EMG measurement of Zygomaticus was comparable with the levels reported by Epstein (1990) and somewhat higher for Corrugator. The within-dyad correlations of the benchmark amplitudes for Zygomaticus and Corrugator were $r = .21$, $p = .27$ and $r = -.12$, $p = .53$, respectively. These results indicate proper measurement of both muscle sites which confirmed the impression gained by visual inspection of parallel video and EMG recordings.

3.3.2. Facial expression synchrony

Figure 2 samples the EMG time series of the Zygomaticus muscle activations captured in two dyads alongside the resulting WCLC parameter distribution along the different time lags. Additionally, Figure 2 shows the EMG time series and WCLC results of a pseudo-interaction analyzed in this study. The first dyad shown in the figure exhibited particularly low levels of synchrony and the second dyad particularly high levels. This can be seen both by visually inspecting the convergence of the two time series (in the middle panel, the time series converge much more) and by the difference in the WCLC parameters. Moreover, in the pseudo-interaction, there is also considerably less synchrony. The distribution of mean WCLC synchrony across the applied time lags for both genuine and pseudo-interactions are illustrated in Figure 3 for Zygomaticus (smiling) and in Figure 4 for

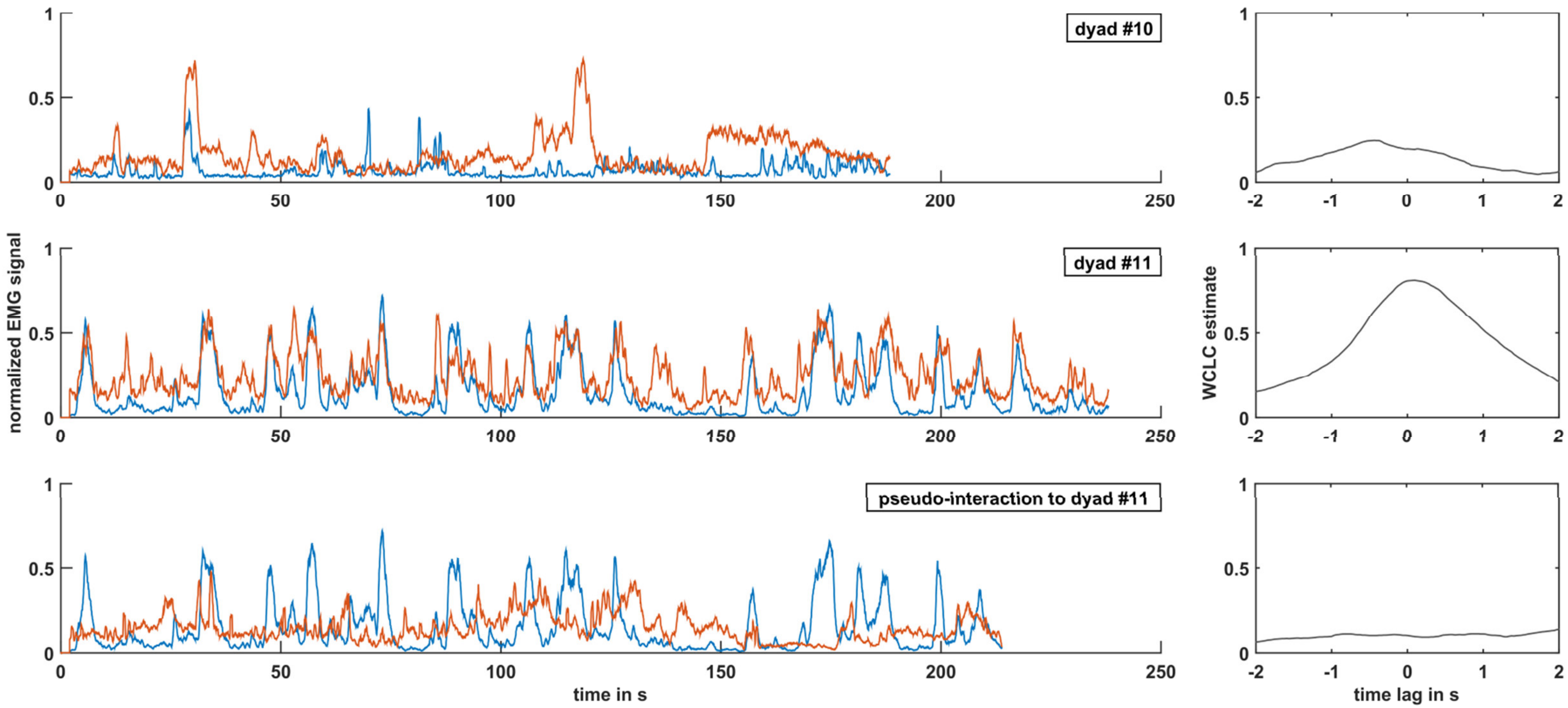


Figure 2. Illustration of the Zygomaticus activation time-series pairs and the corresponding windowed cross-lagged correlation (WCLC) distributions of two dyads (#10 & #11) in the study and of the pseudo-interaction corresponding to dyad #11. Overall synchrony in dyad #10 = 0.11 and in dyad #11 = 0.40.

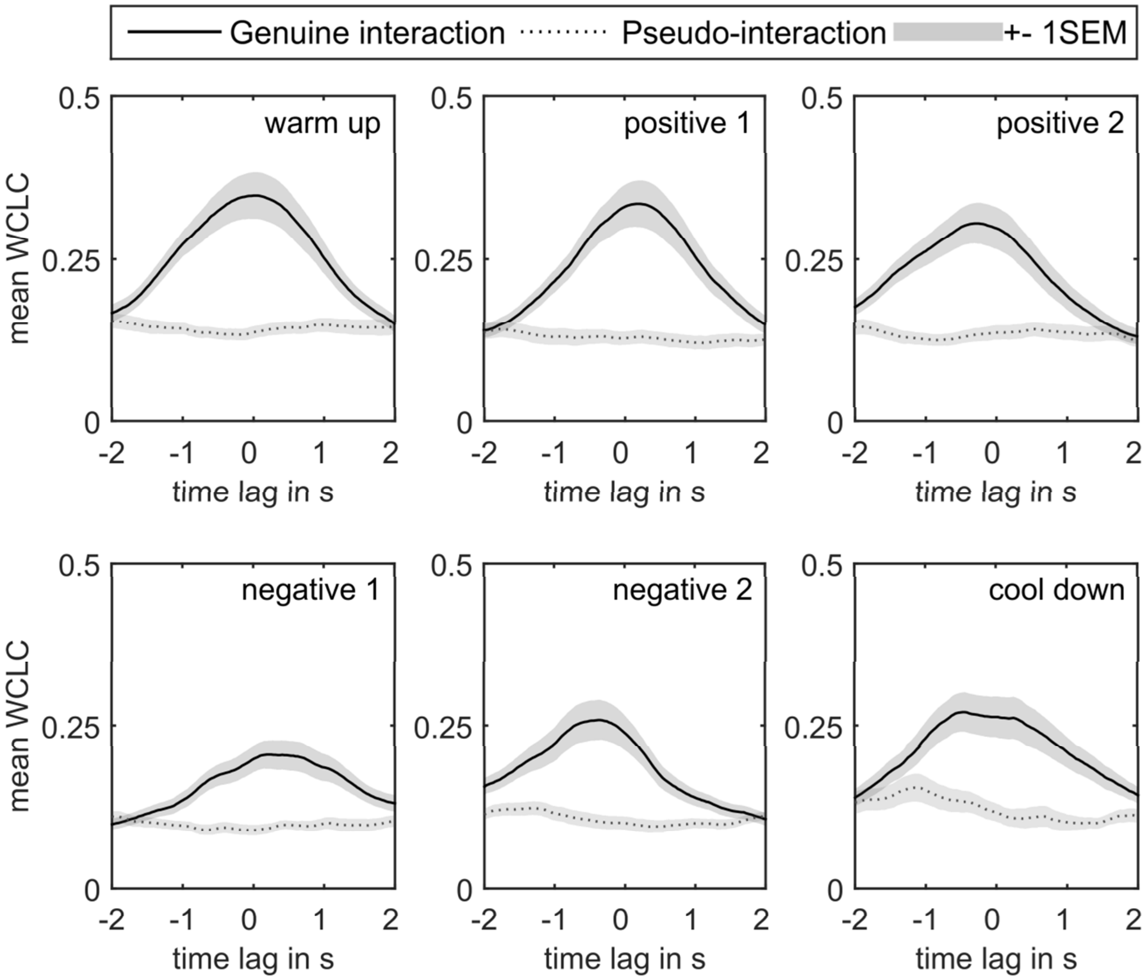


Figure 3. Distribution of mean Zygomaticus (smiling) mimicry estimates along the different time-lags of the windowed cross-lagged correlation (WCLC) analysis for each interactional phase for both genuine (solid line) and pseudo-interactions (dotted line). The shaded gray areas represent ±1 standard error of the mean.

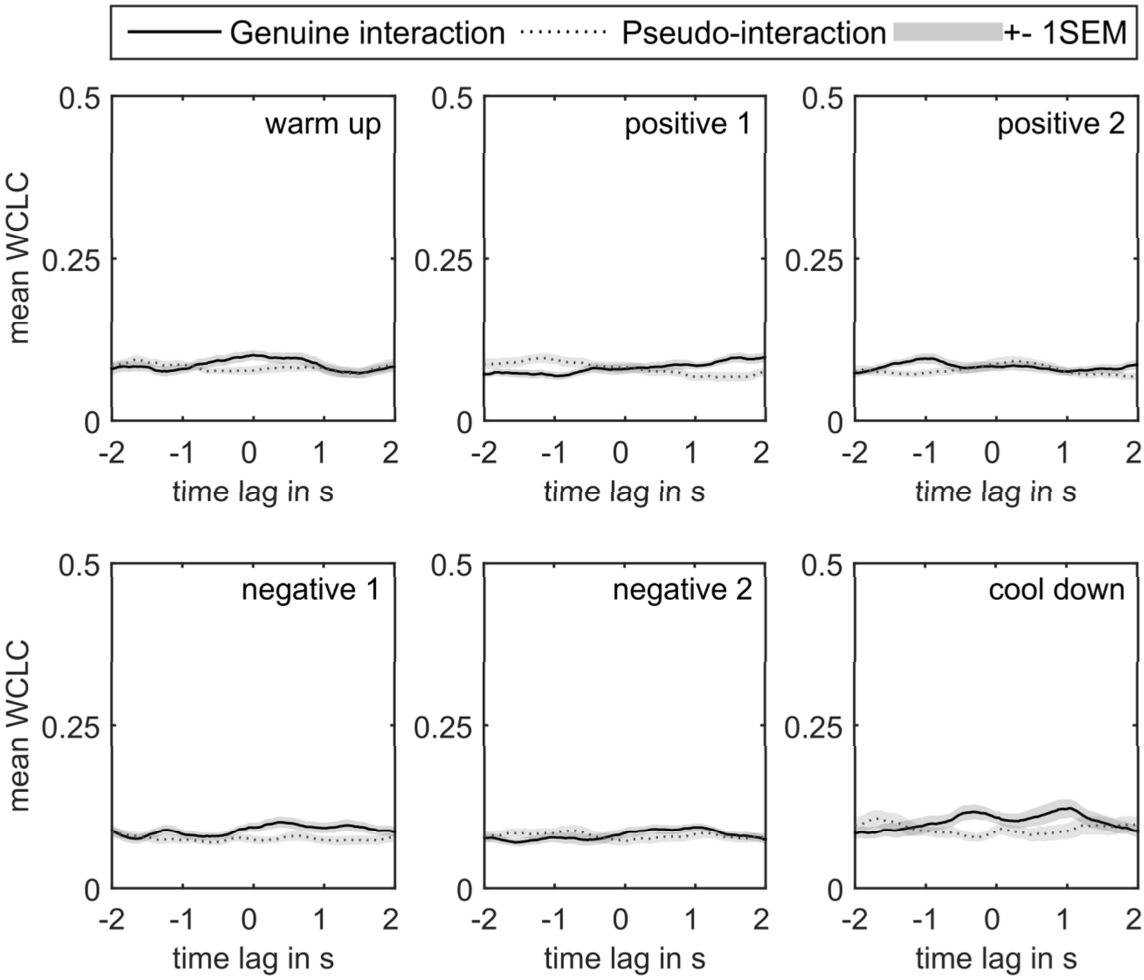


Figure 4. Distribution of mean Corrugator (frowning) mimicry estimates along the different time-lags of the windowed cross-lagged correlation (WCLC) analysis for each interactional phase for both genuine (solid line) and pseudo-interactions (dotted line). The shaded gray areas represent ±1 standard error of the mean.

Corrugator (frowning). In the three-way repeated measures ANOVA on WCLC synchrony, significant main effects of muscle site (F(1,29) = 88.3; p < .001; *partial* η^2 = .75), interaction type (F(1,29) = 45.4; p < .001; *partial* η^2 = .61), and phase (F(1,29) = 10.6; p < .001; *partial* η^2 = .27) emerged. Significant two-way interactions were found for muscle site by interaction type (F(1,29) = 33.2; p < .001; *partial* η^2 = .53) and muscle site by phase (F(1, 29) = 13.3; p < .001; *partial* η^2 = .31). The three-way interaction muscle site by interaction type by phase was also significant (F(1, 29) = 3.8; p = .003; *partial* η^2 = .31). As can be seen in Figures 3 and 4, smiling but not frowning synchrony in genuine interactions could be statistically distinguished from chance level synchrony (pseudo-interactions). Supporting hypotheses 1 and 2, this differential effect held true for all of the six interactional phases, when tested individually using paired samples t-tests (cf. Table 1). Differences between interactional phases were explored for Zygomaticus (smiling) mimicry. As can be seen in Table 2, the pattern of comparisons indicated that there was less Zygomaticus (smiling) mimicry in negatively valenced as opposed to non-negative interactional phases.

Table 1

T-values and effect sizes for pairwise comparisons of genuine vs. pseudo-interactions by interaction type and muscle site.

	Zygomaticus (smiling)		Corrugator (frowning)	
	t (df = 29)	d_z	t (df = 29)	d_z
Warm up	5.93	1.08***	0.53	0.10
Positive person 1	5.13	0.94***	0.03	0.01
Positive person 2	5.52	1.01***	0.98	0.18
Negative person 1	4.78	0.87***	1.61	0.30
Negative person 2	6.05	1.11***	0.14	0.03
Cool down	4.66	0.85***	1.27	0.23

*** p < .001

Table 2

Mean pairwise differences in WCLC mimicry estimates between the different interactional phases for Zygomaticus (smiling).

Interactional phase	Warm up	Positive 1	Positive 2	Negative 1	Negative 2	Cool down
Warm up	–	0.02	0.03 †	0.10 ***	0.07 ***	0.04 †
Positive 1	-0.02	–	0.01	0.08 ***	0.05 *	0.02
Positive 2	-0.03 †	-0.01	–	0.07 **	0.04 †	0.01
Negative 1	-0.10 ***	-0.08 ***	-0.07 **	–	-0.03	-0.05 †
Negative 2	-0.07 ***	-0.05 *	-0.04 †	0.03	–	-0.03

Note: The differences are calculated for row > column. Thus positive values represent the row estimate outscoring the column estimate. † $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$ (all p-values were corrected for family wise error using Bonferroni correction).

In support of hypothesis 3, smiling synchrony showed high internal consistency over the course of the interaction (*Cronbach's α* = .93). Frowning synchrony did not provide sufficient internal consistency (*Cronbach's α* = .69) matching the low internal consistencies of the two pseudo-interaction conditions (*Cronbach's α* = .66 and .69 for smiling and frowning, respectively). These results indicate that smiling but not frowning synchrony was sufficiently reliable over the course of the interaction and under different conditions (change of conversational topics throughout the interaction).

3.3.3. Timing of facial expression synchrony

Figure 5 illustrates the differences between genuine and pseudo-interactions in number of WCLC peaks throughout the interaction for the nine analyzed time lag segments. Supporting hypothesis 4, the inner segment of ±203 ms around time lag 0 contained significantly more WCLC peaks in genuine than in pseudo-interactions ($t(29) = 5.72$; $p < .001$; *Cohen's d* = 1.21). This indicates that the WCLC analysis detected significant smiling synchrony within time lags below 203 ms. The four segments adjacent to the inner segment (two in each time lag direction) also contained significantly more WCLC peaks in genuine than in pseudo-interactions (*t*s(29) = 3.77–6.55; *p*s = .001 – <.001; *Cohen's d*s = 0.78 – 1.33). These findings, that remained significant when correcting for multiple testing, indicate that smiles were predominantly synchronized with maximum delays of ca. 1000 ms.

3.3.1. Additional analyses: Counter-mimicry

When analyzing negative correlations (asynchrony/counter-mimicry) within muscles, significant differences in counter-mimicry emerged between genuine and pseudo-interactions

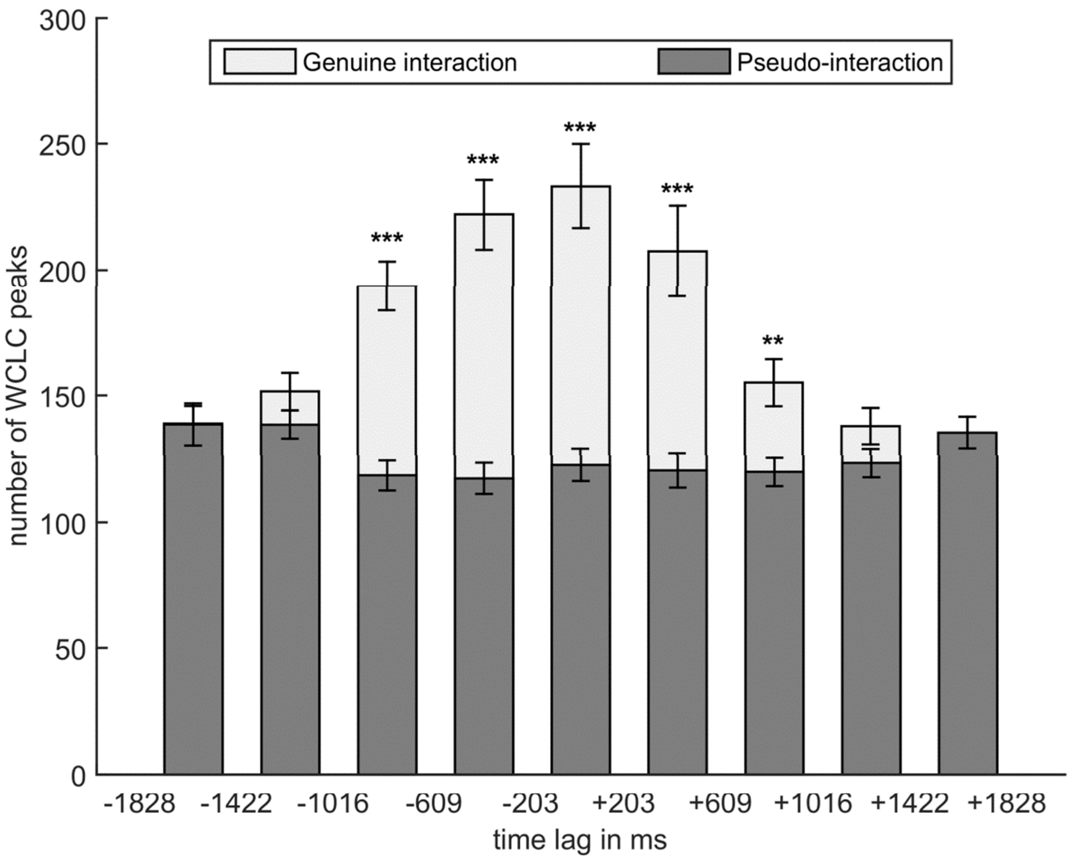


Figure 5. Number of Zygomaticus (smiling) mimicry peaks occurring in varying time lag segments for genuine (light grey bars) and pseudo-interactions (superimposed dark grey bars). Error bars represent standard error of the mean.
** $p < .010$; *** $p < .001$

for the Zygomaticus ($F(1,29) = 44.9$; $p < .001$; *partial* $\eta^2 = .61$). However, the effects were in the opposite direction than the effects for mimicry: In all interactional phases pseudo counter-mimicry outscored genuine counter-mimicry (ts(29) = -8.2 – -4.1, all ps < .001, *Cohen's d*s = -1.51 – -0.78). Concerning Corrugator, no significant differences emerged ($F(1,29) = 0.1$; $p = .91$; *partial* $\eta^2 < .001$).

3.4. Discussion

In this study, a method for quantifying nonverbal synchrony of time series data (windowed cross-lagged correlation; WCLC) was used to quantify the temporal dynamics of emotional facial mimicry. The suitability of this approach was tested. Facial expressions were continuously measured with EMG in face-to-face dyadic interactions. Mimicry was analyzed of Zygomaticus Major (smiling muscle) and Corrugator Supercilii (frowning muscle) contractions during the discussion of positive and negative life events of the interaction partners. As hypothesized, significant smiling synchrony was detected by the WCLC analysis compared to a control condition of pseudo-interactions. Smiles were predominantly synchronized within 1000ms and a significant portion of these as quickly as within 200ms. Construct validity and parameter stability of the analysis appeared to be high.

In accordance with other studies investigating non-verbal synchrony with WCLC in face-to-face interactions, in study 1, pseudo-interactions were used to simulate chance-level emotional facial mimicry. In line with the reports by Bernieri (1988) and Ramseyer and Tschacher (2011), this approach resulted in genuine mimicry outscoring pseudo-mimicry. The effect sizes for overall Zygomaticus (smiling) mimicry in the different interactional phases (ds = 0.85–1.11) were considerably larger than the effect sizes reported by Ramseyer and Tschacher (2011) (*Cohen's d*s = 0.50–0.59), indicating that the analysis here provided a higher signal-to-noise ratio. This difference is possibly explained by the fact that, unlike Ramseyer and Tschacher, in this study, a significance-threshold was employed for the WCLC coefficients in order to suppress non-significant synchrony. Moreover, all negative correlation coefficients marking asynchrony between the time series were suppressed.

There was no clear evidence of Corrugator (frowning) mimicry in the dyads of study 1. In the light of findings that have shown that the Corrugator is reliably deactivated in response to positive stimuli in general (Larsen, Norris, & Cacioppo, 2003) and positive facial expressions in particular (Dimberg et al., 2000), one might have expected Corrugator (frowning) mimicry at least in the positive interaction phases because the Corrugators of both participants should relax during active smiling. In facial mimicry studies based on stimulus presentations via computer, this deactivation becomes evident when signal-change to baseline is calculated. This baseline is usually part of the within-trial pre-stimulus interval (e.g. Dimberg et al., 2000; Likowski, Mühlberger, Seibt, Pauli, & Weyers, 2008) or even a neutral expression (e.g. Hess & Blairy, 2001) in order to control for possible unrelated muscle activations. The mimicry responses (both of activation and deactivation) then usually are in a range of several µV (e.g. ±3 µV in Dimberg et al., 2000). In the continuous EMG assessment of study 1, muscles were considered deactivated, when a "calm" baseline was reached. This baseline then was thought to represent zero activation plus noise. A noise level of maximum 5µV RMS was accepted, when checking signal quality before the interactions. When muscles were activated, as in active frowning or smiling, the RMS EMG amplitude in most participants reached levels of more than 100µV RMS (cf. also Epstein, 1990). This is because the facial movements we recorded were much less subtle than the ones usually assessed in facial mimicry research. Thus, this study investigated particularly overt facial expressions, but in turn did not readily detect deactivation of muscles in the way the aforementioned studies did. The analysis method appears thus to be specifically useful to detect overt emotional facial mimicry as opposed to covert emotional facial mimicry.

By finding Zygomaticus (smiling) to be mimicked by interaction partners to a larger extent than frowning, the findings by Hess and Bourgeois (2010) were confirmed in this study. A possible explanation for the differential effect related to smiling versus frowning synchrony could be that both Hess and Bourgeois (2010) and this study investigated affiliative situations. In these types of situations, frowning, which may be considered a non-affiliative signal, is less likely to be synchronized than the affiliative signal smiling (e.g.

Hess, Blairy, & Kleck, 2000). The notion that the interactions in this study were affiliative in nature is also reflected by the finding that counter-mimicry reactions did not occur on a significant basis. Counter-mimicry is known to particularly be present in competitive as opposed to affiliative situations (e.g. Lanzetta & Englis, 1989). Moreover, counter-mimicry in the Zygomaticus (smiling) muscle was significantly suppressed in the affiliative interactions. This further underlines the importance of emotional facial mimicry of smiles in affiliative interactions.

When further disentangling the temporal dynamics of smiling synchrony, Zygomaticus (smiling) mimicry was found within time lags up to 200 ms, thus corroborating the findings by Heerey and Crossley (2013). Heerey and Crossley assumed that mimicry within 200 ms after smile onset reflects an anticipated response because perceptive processing in addition to subsequent motor output would take longer than these 200 ms. They found that genuine but not polite smiles were mimicked by interaction partners within 200 ms. It is thus likely that the high proportion of low time-lag synchronizations found in this study reflects a high proportion of reciprocated genuine smiles in the interactions. This interpretation also fits in well with the findings of Hess and Bourgeois (2010), who found that in comparison to genuine smiles, polite smiles were only rarely expressed in first encounters. Because of this cross-validation with existing findings in the literature, the construct validity of the outcome parameter of our WCLC analysis appears to be high.

Some limitations to the study design specific to the findings of study 1 need mentioning. First, due to the convenience sampling, the age range was larger than in most other experiments on facial EMG. Even though studies on the topic suggest that neither facial EMG nor facial mimicry are affected by age (Bailey & Henry, 2009; Hühnel, Fölster, Werheid, & Hess, 2014), a significant negative correlation of age and Zygomaticus activation levels was found (reported in study 2, section 4). However, controlling for age in all analyses did not change the results. Second, the EMG assessment was restricted to two muscle sites and the emotional event types to happiness and anger situations, so that conclusions about the mimicry of other facial expressions such as fear or disgust are limited. Third, the study was conducted in a Western European country and culture and thus our findings need replication in other cultural areas. Finally, because the study design was not completely counterbalanced, it cannot be ruled out that sequencing effects produced the differential results for positive and negative event types. Nevertheless, the core research question of this study (whether or not emotional facial mimicry can be assessed by using EMG and WCLC) can still be answered by the data. For example, the findings in the "warm up" phase in which the participants did not yet know whether they would start with positive or negative stories did not differ from the general findings in terms of finding Zygomaticus (smiling) mimicry ($p < .001$; $d = 1.08$) but not Corrugator (frowning) mimicry ($p = .60$; $d = 0.10$) when comparing to pseudo-interactions. Moreover, the warm up period seems to be a good proxy in terms of mimicry of Zygomaticus movements in the interaction overall. Across the various interactional phases, Zygomaticus (smiling) mimicry showed a Cronbach's $\alpha = .93$. The corrected item-to-scale correlation of the warm up period with respect to the overall emotional facial mimicry in the interaction was $r = .87$ for Zygomaticus. Thus, the order of valence blocks does not seem to have influenced the feasibility and validity of the analytic approach presented in this study.

The WCLC approach presented here could be used to address research questions on how the temporal dynamics of emotional facial mimicry in dyadic interactions are affected by experimental manipulations (such as valence) or inter-individual differences related to interpersonal behavior, such as social cognition (Heerey, 2015). Another important unanswered research question that could be addressed is how the temporal dynamics affect the quality of social interactions. This may be particularly indicated for investigations aiming at understanding social interaction skills deficits in clinical populations, in which facial mimicry deficits might play a role, such as depression (Wexler, Levenson, Warrenburg, & Price, 1994), autism (McIntosh, Reichmann-Decker, Winkielman, & Wilbarger, 2006), or schizophrenia (Varcin et al., 2010). Moreover, WCLC is not restricted to EMG data and also likely to provide valid results for other methods measuring facial expressions such as automated tracking of facial expressions from video recordings of classical two-dimensional cameras (Messinger et al., 2009) or newly from three-dimensional depth cameras (e.g. Zhang, 2012).

In sum, the findings provide good evidence to support using behavior time series analysis, and WCLC in particular, for quantifying the temporal dynamics of facial expression synchrony. WCLC largely maintains the temporal resolution of the input data, relies on an objective assessment of movements, offers a high signal-to-noise ratio, and provides high construct validity. Using the analysis, this study for the first time was able to provide EMG data derived from face-to-face interactions that support a rapid, presumably anticipated, synchronization of smiles within 200 ms. The method could be used to investigate this phenomenon in more depth in both healthy and clinical populations. Studies 2 and 3 of this dissertation will thus make use of this method.

Chapter 4: Study 2 – Towards an understanding of the interpersonal consequences of expressive negative symptoms associated with schizophrenia

4.1. Introduction

In chapter 1 it was presented that social impairments in schizophrenia are strongly related to the negative symptoms (Bowie et al., 2008; Couture et al., 2011) that are comprised of motivational and expressive negative symptoms (Horan et al., 2011; Strauss, Hong, et al., 2012b). Motivational negative symptoms were defined in chapter 1 as a lack of motivation to engage in pleasant activities along with a diminished recollection and anticipation of receiving pleasure from such activities. Expressive negative symptoms were defined in chapter 1 to be comprised of reductions in several domains of nonverbal communication, such as facial expressiveness, vocal prosody, gesturing, and quantity of spoken words (Horan et al., 2011). Motivational negative symptoms such as social anhedonia have long been discussed as a risk-factor for the onset of psychosis (Chapman, Chapman, Kwapil, Eckblad, & Zinser, 1994; Gayer-Anderson & Morgan, 2013; Kendler, Thacker, & Walsh, 1996) and have been shown to relate to lower social functioning even in non-clinical samples (Blanchard et al., 2011; Corcoran et al., 2011). Expressive negative symptoms are also discussed to predate the onset of psychosis (Piskulic et al., 2012; Schiffman et al., 2004; Walker et al., 1993). However, little is known about how expressive negative symptoms affect social outcomes, neither in clinical nor in non-clinical samples (Lavelle et al., 2014).

Because expressive negative symptoms are inherently reductions in nonverbal behavior, they should negatively affect everyday interactions and on the far end increase the likelihood of being rejected by interaction partners, a precursor of diminished social networks (Back, 2015; Hooley, 2010; Thorup et al., 2006). This is supported by evidence showing that the interaction partners of patients with schizophrenia respond negatively to reductions in nonverbal behavior (Krause, Steimer, Sänger-Alt, & Wagner, 1989; Lavelle, Dimic, Wildgrube, McCabe, & Priebe, 2015; Lavelle et al., 2013; Penn et al., 2000; Riehle et al., 2015). Since expressive negative symptoms have been shown to play a minor part in explaining more globally assessed social functioning in schizophrenia (Galderisi et al., 2014) they may particularly affect early outcomes of face-to-face interactions, such as being liked by the interaction partner. The formation of mutual liking between interaction partners, in turn, is known to heavily rely on conveying positivity via facial expressions (Tickle-Degnen & Rosenthal, 1990, cf. section 1.4). It might be this conveying of positivity that is impaired in people with expressive negative symptoms: Positive facial expressions rather than negative facial expressions have been found to be affected by the reduced emotional expression both in schizophrenia (Blanchard et al., 2004; Kring & Moran, 2008; Mattes et al., 1995) and in non-clinical samples (Leung et al., 2010; Llerena et al., 2012). However, a reduction in positive facial expressions has not yet been investigated as a possible behavioral marker of expressive negative symptoms in relation to the liking that is formed in a face-to-face interaction.

Another important aspect of mutual liking that was defined in chapter 1 is the synchronization of movements between interaction partners or behavioral mimicry (Lakin & Chartrand, 2003; Tickle-Degnen & Rosenthal, 1990) and recent studies have shown that people with schizophrenia exhibit deficits both in the voluntary and spontaneous mimicry of body movements (Kupper et al., 2015; Lavelle, 2011; Raffard et al., 2015; Varlet et al., 2012). These deficits have been found to be associated with negative symptoms (Kupper et al., 2015), to be associated with more negative social evaluations of patients (Lavelle, 2011)[10], and to be present in un-affected relatives of people with schizophrenia (Del-Monte et al., 2013). Synchronization of expressive facial movements is also known as emotional facial mimicry (Hess & Fischer, 2013, cf. section 1.5). Whether or not synchronization of facial expressions is impaired in schizophrenia is unclear, since the only two studies on facial mimicry produced conflicting results and did not assess facial expressions within social interactions (Kring et al., 1999; Varcin et al., 2010).

Taken together, the evidence suggested that expressive negative symptoms could negatively affect face-to-face interactions and their social outcome through a lack of the amount of shown and synchronized positive facial expressions and that this basic mechanism should also be observable in non-clinical samples. Study 2 therefore tested the following hypotheses:

1. In a non-clinical sample, expressive negative symptoms are reflected in reduced facial expression and emotional facial mimicry within a dyadic face-to-face interaction.
2. Expressive negative symptoms trigger more negative evaluations on sides of the interaction partner.
3. Reduced smiling behavior (reduced amounts of positive expressions and of mimicry of smiles) would be associated with more negative evaluations by the interaction partner.
4. Negative symptoms and reduced smiling behavior would be reflective of diminished social support networks

4.2. Methods

4.2.1. Sample

Study 2 analyzed the same sample analyzed in study 1 and as has been described in section 3.2.1. That is, data of 30 dyadic interactions ($N = 60$) were analyzed in study 2. Table

[10] Negative symptoms were not associated with the synchronization deficit in Lavelle's (Lavelle, 2011) study, but were associated with the social evaluation.

3 (cf. section 4.3) gives an overview on sample characteristics and the distribution of the different measures used in study 2.

4.2.2. Materials and Instruments

In addition to the assessments described in section 3.2.2 that ruled out a clinical diagnosis and tested for sufficient verbal IQ, several instruments were used to test the more clinically focused hypotheses of study 2.

4.2.2.1. Clinical Assessment Interview for Negative Symptoms

Negative symptoms in all participants were assessed with the Clinical Assessment Interview for Negative Symptoms (CAINS; Kring et al., 2013), a semi-structured interview that assesses negative symptoms as impairments in “Motivation and Anticipation of Pleasure” (CAINS-MAP) and “Expressiveness” (CAINS-EXP). Based on the information given by participants in the interview, the CAINS-MAP subscale assesses the motivation to engage in social, vocational, and recreational activities, as well as the amount of pleasure people recollect and anticipate to receive from these activities. The observer-rated CAINS-EXP subscale explicitly assesses reductions in the domains of facial expressiveness, vocal prosody, gesturing, and quantity of speech. The CAINS-MAP subscale includes nine items and the CAINS-EXP subscale four items. Each item is rated from 0 (= no impairment) to 4 (= severe impairment) according to detailed anchor points and sum scores are calculated for each scale. Three trained raters conducted the CAINS interviews with the participants (inter-rater reliabilities were .75 for CAINS-MAP and .72 for CAINS-EXP).

4.2.2.2. Social Phobia Scale & Social Interaction Anxiety Scale

Social anxiety was assessed with the Social Phobia Scale and the Social Interaction Anxiety Scale (SPS/SIAS; Stangier, Heidenreich, Berardi, Golbs, & Hoyer, 1999). Both scales consist of 20 items which can be rated on a 5-point agreement scale from 0 (= “not at all accurate”) to 4 (= “completely accurate”). The items in the SPS tap general socially phobic situations such as being in public and the center of other people's attention, whereas the SIAS taps social anxiety related specifically to social interactions. Sum scores for each scale were calculated.

4.2.2.3. Social Support Questionnaire

The size of and satisfaction with the social support network was assessed with the 6-item version of the Social Support Questionnaire (SSQ; Leppin, Quast, & Sarason, 1986). The items in this questionnaire consist of questions such as "Whom can you count on to console you when you are very upset?". In the German version used here, these items were translated as first person statements in the form of "When I am very upset, I can count on the following people to console me". Each item consists of two different parts, one assessing social network size and one satisfaction with the social support network. First, the participant is asked to fill in the initials of up to eight different people or to check "no one" (social support network size). Second, the participant is asked to estimate the degree to which the support is helpful for him/her (social support network quality) on a 4-point Likert scale from 1 (= "not at all") to 4 (= "very much"). Social support network size was calculated by summing all different people named across the six items (possible range 0-64). Satisfaction with the social support network was calculated by summing the answers of all quality items (possible range 6-24).

4.2.2.4. Willingness to Interact Scale

The Willingness to Interact Scale (WILL; Coyne, 1976) is a validated 6-item scale for the assessment of the willingness of a person to interact with a specified other person. It was chosen to capture the social outcome (*rapport*) after the face-to-face interactions. Items (e.g. "How willing would you be to ask this person for advice") are rated on a 5-point Likert scale ranging from 1 (= "definitely willing") to 5 (= "definitely unwilling"). For this study, a seventh item "How willing would you be to get to know the person better?" was additionally included. Participants completed the WILL after the face-to-face interactions and the questions targeted their interaction partner. The sum of the reverse-scored items was used as a participant's social evaluation of the interaction partner. Higher scores thus represented more willingness for future interactions with the interaction partner and the internal consistency of this sum score was Cronbach's $\alpha = .88$.

4.2.2.5. Electromyography measurement of facial expressions

Facial EMG was measured as described in section 3.2.4. The EMG activations of two muscle sites per participant were recorded throughout the dyadic interactions: Zygomaticus Major (smiling) and Corrugator Supercilii (frowning).

4.2.3. Procedure

The procedures of the study have been described in section 3.2.3. That is, the symptom rating and the assessment of inclusion criteria was conducted on a separate day before the participants engaged in a dyadic face-to-face interaction. EMG was measured continuously throughout the interactions form both dyad members. The interactions consisted of the discussion of a positive and negative life event per participant and an initial warm up period and a subsequent cool down period. After the interactions, participants evaluated each other with the WILL.

4.2.4. Data analysis

4.2.4.1. Handling of the dyadic data structure

In this section, some basic terms and concepts in the analysis of dyadic data will be presented in accordance with Kenny, Kashy, and Cook (2006), who are a standard reference in for the analysis of data derived from dyads. Study designs that look at interpersonal outcomes of dyadic interactions produce nested data in which individual participants represent level-1 units nested within dyads that represent level-2 units. Accordingly, here, level 1 will also be referred to as the *individual level* and level 2 as the *dyad level*. In such a study design, measures that were derived once the interaction had started (i.e. EMG-data and social evaluation with the WILL) have to be considered *non-independent*, meaning that both dyad-members are assumed to have contributed to any outcome on the individual level. That is, the interactional behavior of person A will never be independent of the behavior of person B and vice versa. In contrast to this, all measures obtained before persons A and B first interact with one another, may be considered *independent*, if the two people forming a dyad do not have an a priori relationship with one another (as for example in studies on family interactions). *Non-independence* may be statistically tested for, but Kenny (2015) argues that a test for non-independence in samples of less than 35 dyads (as is the case in this study) lacks sufficient power. Kenny for such cases suggests assuming that there is non-independence in the data. This non-independence has to be accounted for in the analyses because otherwise the assumption of independent observations (or uncorrelated residuals) in standard inferential statistics such as ANOVA or regression would be violated.

One solution to the problem of non-independence is to understand the dyadic data structure as a repeated measures design. Consider an example, where the focus of a study was the difference between people of a group A and people of a group B that had formed dyads consisting of one group member each. Group then would represent a within-subject factor on the dyad level. Obviously, such an analysis is only feasible when there is a grouping factor that distinguishes persons A and B within the dyad. For example, when interactions of heterosexual couples were investigated, the two people forming a dyad would be *distinguishable* by their sex (cf. Kenny et al., 2006). If, however, no such distinguishing factor was present, as is the case in this study where same-sex dyads were investigated that were not grouped any further, the two individuals forming the dyad are labelled *indistinguishable*. In contrast to this, study 3 (section 5) involved *distinguishable dyads* and the handling of the data structure specific to study 3 will be presented in section 5.2.5. Study

1 looked at emerging effects only at the dyad-level (synchrony between the two interaction partners), which is why non-independence did not have to be accounted for in study 1.

Since in study 2, non-independence had to be accounted for for *indistinguishable dyads*, two of the approaches suggested by Kenny and colleagues (2006) for the analysis of indistinguishable dyads will be presented. Both approaches aim at accounting for the non-independence in the data by accounting for the dyad-level when analyzing outcomes obtained on the individual level (e.g. social evaluation with the WILL) and build on one another. First, if one is interested in investigating bivariate correlations that include at least one non-independent variable, the individual scores of the two dyad members may be summed for both variables and the within-dyad sums may then be calculated (Kenny et al., 2006). This approach is particularly useful to gain a descriptive overview on the data structure but on the other hand is rather imprecise because summing the variables removes possibly important parts of the within-dyad variance.

Second, as an alternative to a regression analysis Kenny and colleagues (2006) suggest estimating the individual contribution of each dyad-member to an individual outcome via *actor* and *partner* effects in the so called *Actor-Partner-Interdependence Model* (APIM; Kashy & Kenny, 1999; Kenny et al., 2006). In the APIM, the contributions of both persons A and B (predictors) to the outcomes of both persons A and B (criterion) are modelled reciprocally. The *actor effect* models the contribution of the characteristic of a person (the actor) on a predictor X to the characteristic of that same person on a criterion Y. The *partner effect* models the contribution of the characteristic of the interaction partner on that same predictor X to the characteristic of the actor on the criterion Y. For example, in this study, social evaluation with the WILL is hypothesized to be predicted by the CAINS-EXP score of the interaction partner. Thus, a significant partner effect would be expected here. Figure 6

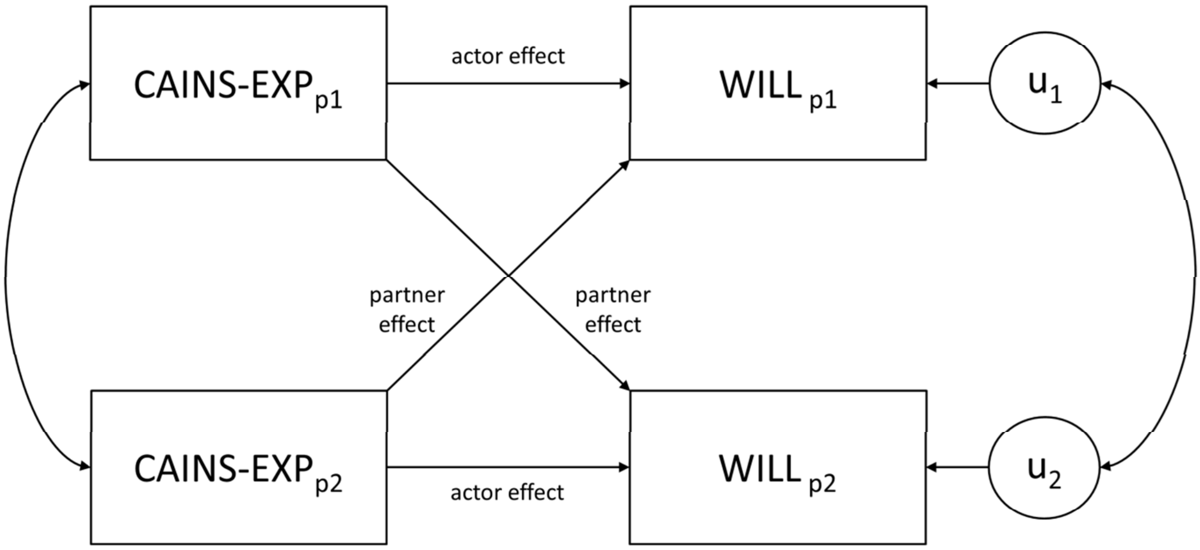


Figure 6. Conceptual illustration of the Actor-Partner Interdepence Model [46] for indistinguishable dyads modelled with multilevel modelling. Because there is no theoretically meaningful distinction between the two interaction partners, the crossing arrows represent a single partner effect and the straight arrows a single actor effect. These effects are modelled reciprocally in a single analysis. CAINS-EXP = Clinical Assessment Interview for Negative Symptoms; WILL = Willingness-To-Interact Scale; p1 and p2 refer to person 1 and 2 within a dyad.

illustrates a basic APIM for this example. Note that both dyad members at the same time contribute to the actor effect (prediction of their own outcome) and to the partner effect (prediction of the partner's outcome) and that these effects are modelled reciprocally. Kenny and colleagues (2006) suggest multilevel modelling (MLM) for the estimation of the APIM in indistinguishable dyads. SPSS (IBM corp., NY, USA) may be used to estimate the APIM with MLM. Kenny and colleagues suggest that subjects, nested within dyads, are set as repeated measures, and both the actor and partner scores of a predictor are used for modelling the criterion. Compound symmetry is used as the structure of the variance-covariance matrix to account for equally distributed random intercepts across dyads. The effect sizes of the predictors in the model (i.e. of the actor and the partner effect, respectively) can be calculated by converting the t-values of the MLM parameter estimation to *r* via the transformation

$r = t/\sqrt{df + t^2}$. This r-value represents the effect of the predictor after controlling for the effect of the other predictor in the model, for example the actor after controlling for the partner effect. A correction for the degree of non-independence in the data then has to be applied to this effect size (Kenny et al., 2006). If the non-independence is rather low the results of the MLM will approach the results of a linear multiple regression. The results will diverge from the results of a linear multiple regression with increasing non-independence. Thus, modelling the APIM with MLM is advisable when non-independence may play a role, as is the case in this study. The APIM for indistinguishable dyads can be modelled with MLM using SPSS and a publicly accessible SPSS macro written and provided for by Kenny (2011).

4.2.4.2. Quantification of facial expressions via EMG

The preprocessing of the EMG signals that were continuously recorded throughout the interactions has been described in section 3.2.5. That is, the rectified and smoothed (RMS) EMG-signals were normalized to a range of 0 to 1 using min-max normalization. However, in addition to that, a baseline activation level was calculated as the mean of the 10 s period with the smallest standard deviation in each muscle-site's data. A threshold then was set at this mean plus three standard deviations and a baseline correction was applied to the normalized EMG time-series using this threshold. The resulting baseline corrected EMG time-series were used to calculate the overall mean of the time-series as the level of activation of a muscle-site. By this a single value was obtained for the amount of Zygomaticus (smiling) and Corrugator (frowning) activation for each participant.

4.2.4.3. Quantification of emotional facial mimicry

The WCLC analysis performed in this study has been described in section 3.2.6. However, as Corrugator (frowning) mimicry was not detected in the analyses of study 1, only Zygomaticus (smiling) mimicry was used in study 2. Additionally, in contrast to study 1, in study 2 the mean score of emotional facial mimicry were calculated separately for positive and negative time lags. Note that, as outlined in section 3.2.6, correlations occurring at positive and negative time lags represented dyad-member 2 mimicking dyad-member 1 and correlations at negative time lags represented dyad-member 1 mimicking dyad-member 2. This resulted in a single average Fisher-Z transformed correlation per participant representing the overall degree of smiling being mimicked by this participant. By this, Zygomaticus (smiling) mimicry was assessed on the individual level (cf. section 4.2.4.1).

4.2.4.4. Hypothesis testing

In a first analysis step, descriptive statistics and bivariate correlations of sample characteristics and outcome variables were examined. Correlations that involved a non-independent variable were calculated on the dyad-level only (cf. section 4.2.4.3). Pearson correlations were calculated, but Spearman-Rank correlations were chosen for skewed variables.

In a second step, to judge whether a person's negative symptoms or the negative symptoms of their interaction partner influenced the interpersonal outcomes, *actor* and *partner effects* were analyzed (cf. section 4.2.4.3). This analysis is the preferred method to assess the individual contribution of each dyad-member to an individual outcome (Kenny et al., 2006; Nestler, Grimm, & Schönbrodt, 2015). The contribution of a person's expressive negative symptoms to an interpersonal outcome (Zygomaticus/Corrugator activity, Zygomaticus (smiling) mimicry, evaluation of partner with the WILL) was defined as the actor effect and the contribution of the respective partner's expressive negative symptoms to the outcome as the partner effect (see Figure 6). According to the hypotheses, predominant negative actor effects of CAINS-EXP on the two EMG-activation variables and a predominant negative partner effect of CAINS-EXP on the social evaluation with the WILL were expected. Because of the expectation that reduced smiling behavior would be associated with the social evaluation, actor and partner effects were also examined of Zygomaticus activity and Zygomaticus (smiling) mimicry on the WILL. Additionally, possible actor and partner effects on the interactional outcomes of CAINS-MAP and of the social support network size and quality measures were explored. The aforementioned macro by Kenny (2011) was used to model the respective effects, which were expressed as *r* (cf. section 4.2.4.3). All predictors were centered to the grand mean. All inferential statistics were tested at an α-level of $p = .05$. Medium to large effects could be detected with a power of 80% given the sample size of 30 dyads ($N = 60$).

4.3. Results

4.3.1. Before the dyadic interaction: Negative symptom profiles and conversation content

Negative symptom levels as assessed with the CAINS were generally low (see Table 3 for means). Concerning CAINS-EXP, 53% of participants did not show any impairment (= score of 0; range 0–7). On CAINS-MAP, 60% of participants scored a value of 4 or lower (range: 0–24). The intensity ratings of both positive and negative events were unrelated to either CAINS-MAP (positive: $r = .04$; $p = .75$; negative: $r = .03$; $p = .85$) or CAINS-EXP (positive: $r = .01$; $p = .94$; negative: $r = .10$; $p = .48$).

4.3.2. On the dyad level: Correlations of symptom ratings, social behavior, and social evaluation

Table 3 shows descriptive statistics and inter-correlations of the variables. As can be seen, on the dyad-level, CAINS-EXP was not related to either Zygomaticus or Corrugator activity, was negatively associated with Zygomaticus (smiling) mimicry on trend-level, and was significantly negatively correlated with the social evaluation (WILL) and with satisfaction with the social support network. Of note, CAINS-MAP scores were significantly

Table 3

Descriptive statistics and inter-correlations of demographics, symptom assessments, social behavior, and social evaluation

		M (*SD*)	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1.	Age	35.1 (12.2)	–										
2.	Years of education	16.1 (3.09)	-.01	–									
3.	CAINS-MAP [a]	5.07 (4.65)	.13	.04	–								
4.	CAINS-EXP [a]	1.42 (1.88)	.19	.02	.67**	–							
5.	SPS [a]	7.29 (5.39)	-.09	-.15	-.09	-.04	–						
6.	SIAS [a]	14.9 (7.68)	-.07	-.17	.10	.06	.70***	–					
7.	SSQ network size [a]	7.18 (3.22)	-.33*	.24†	-.28*	-.14	.12	-.08	–				
8.	SSQ quality [a]	21.5 (2.36)	-.06	.11	-.39**	-.32*	-.16	-.25†	.11	–			
9.	Zygomaticus activity [a, b]	0.11 (0.06)	-.70**	-.21	-.34†	-.29	.11	-.03	.10	.20	–		
10.	Corrugator activitiy [a, b]	0.03 (0.02)	.24	-.18	.10	.07	.06	-.06	-.28	-.04	.04	–	
11.	Smiling mimicry [a, b]	0.21 (0.09)	-.41*	-.21	-.47*	-.32†	.10	-.10	.25	.55**	.47*	-.14	–
12.	WILL [b]	23.5 (4.56)	-.02	.16	-.33†	-.44*	-.15	-.13	-.08	-.02	-.06	.17	-.05

Note. CAINS-MAP = Clinical Assessment Interview for Negative Symptoms, Motivation and Anticipation of Pleasure subscale; CAINS-EXP = CAINS Expressiveness subscale; SPS = Social Phobia Scale; SIAS = Social Interaction Anxiety Scale; SSQ = Social Support Questionnaire; WILL = Willingness-to-interact scale. [a] Correlations are Spearman-Rank Correlations.
[b] Correlations were calculated on the dyad-level and are based on $n = 30$ dyads. Means and *SD*s of these variables refer to the individual level.
† $p < .10$; * $p < .05$; ** $p < .01$; *** $p < .001$

negatively associated with smiling behavior (significant for Zygomaticus (smiling) mimicry; trend-level for Zygomaticus activity) and with smaller and less satisfying social support networks. CAINS-MAP was also related to the social evaluation with the WILL on trend-level. Additionally, higher age was associated with less smiling behavior in the interactions and with smaller social support networks. None of the social behavior variables were related to the WILL, but Zygomaticus (smiling) mimicry was significantly positively associated with participants' satisfaction with their social support network.

4.3.3. On the individual level: Predictors of interactional outcomes

As can be seen in Table 4, the results of the MLM of the Zygomaticus activity on the individual level showed a trend-level significant actor effect (p = .08) and no partner effect (p = .77) for CAINS-EXP. Thus, participants scoring higher on CAINS-EXP showed somewhat less Zygomaticus (smiling) activity in the face-to-face interaction. There was neither an actor nor a partner effect of CAINS-EXP on Corrugator activity. There was, however, a significant negative partner effect of CAINS-EXP on Zygomaticus (smiling) mimicry (p = .03) in that interaction partners of participants rated higher on CAINS-EXP mimicked fewer smiles. Regarding the social evaluation with the WILL, the MLM analysis showed a significant negative partner effect (p = .01) and no actor effect (p = .41) of CAINS-EXP. Thus, participants reported less willingness for future interactions with their interaction-partners when their interaction partners were rated higher on CAINS-EXP. There were no significant actor or partner effects of Zygomaticus activity or smiling mimicry on the WILL.

As also shown in Table 4, the analyses of the CAINS-MAP showed significant negative actor (p = .02) and partner (p = .01) effects for Zygomaticus (smiling) mimicry, so that higher CAINS-MAP scores were related to both mimicking smiles less and being mimicked less. CAINS-MAP was unrelated to either Zygomaticus or Corrugator activity. A

Table 4

Coefficients (r) for actor and partner effects of negative symptoms and of social support on the interactional outcomes.

	CAINS-EXP		CAINS-MAP		SSQ network size		SSQ quality	
	actor	*partner*	*actor*	*partner*	*actor*	*partner*	*actor*	*partner*
Zygomaticus activity	-.24†	.04	-.22	-.22	.06	.06	.19	-.03
Corrugator activity	-.03	-.09	-.08	-.08	-.10	-.03	-.02	-.12
Smiling mimicry	-.15	-.27*	-.26*	-.31**	.25†	.15	.24*	.29*
WILL	-.10	-.37**	-.14	-.26*	-.08	.03	.08	-.01

Note. CAINS-EXP/-MAP = Clinical Assessment Interview for Negative Symptoms expressiveness scale/motivation and anticipation of pleasure scale; SSQ = Social Support Questionnaire; WILL = Willingness-to-Interact Scale.
† $p < .10$; * $p < .05$; ** $p < .01$

negative partner effect (p = .04) of CAINS-MAP on the WILL emerged, resembling the effect of CAINS-EXP but with a smaller effect size. Social support network size was somewhat related positively with mimicking smiles of the interaction partner, as indicated by a trend-level significant positive actor effect (p = .07). Satisfaction with the social support network showed significant positive actor (p = .04) and partner (p = .02) effects for Zygomaticus (smiling) mimicry, so that higher satisfaction with the social support network related to the participant mimicking more smiles and being mimicked more by their interaction partner.

4.4. Discussion

This study examined, in a non-clinical sample, whether expressive negative symptoms impede face-to-face interactions and thus have negative interpersonal consequences. Additionally, the role of reduced smiling behavior in this process as a potential behavioral marker for expressive negative symptoms was examined. As expected, participants were less motivated in future interactions with their interaction partner if this partner exhibited higher expressive negative symptoms. Smiling behavior (i.e. amount of smiling and mimicry of smiles) in the interactions was somewhat related to expressive negative symptoms, but also explained by motivational negative symptoms. Unexpectedly, smiling behavior was not related to the social evaluation by the interaction partners. Both negative symptom domains and mimicry of smiles were, however, related to participants' satisfaction with their social support network.

The finding that interaction partners showed less willingness for future interactions with participants scoring higher on expressive negative symptoms was robust even though symptom levels were low. This mechanism could add to explaining how reduced expressiveness before the onset of psychosis (Piskulic et al., 2012; Schiffman et al., 2004; Walker et al., 1993) might contribute to the deterioration of common prodromal symptoms such as withdrawal, loneliness, and reduced social functioning by a reciprocal process: Being rejected by others will likely terminate an acquaintance on sides of the rejecting person and at the same time might trigger lower motivation for future interactions (even with other people) in the rejected person.

The negative effect of expressive negative symptoms on the willingness for future interactions can be best explained by the fact that the social interactions in this study constituted a first encounter, thus an affiliative situation. In this type of situation, affiliation is usually expressed by displays of positivity and openness (Tickle-Degnen & Rosenthal, 1990). Expressive negative symptoms likely resulted in reductions of these necessary displays, thus leading to rejection by interaction partners. However, it could not be confirmed that smiling behavior mediates the relationship between expressive negative symptoms and negative social evaluations. Reductions in other nonverbal domains such as gesturing (Walther & Mittal, 2016), whole body movements (Kupper, Ramseyer, Hoffmann, Kalbermatten, & Tschacher, 2010; Kupper et al., 2015), and tone of voice (Cohen, Alpert, Nienow, Dinzeo, & Docherty, 2008; Cohen & Hong, 2011), which are also included in the expressive negative symptoms, might have contributed to the more negative social evaluations. This is why different nonverbal domains should be investigated jointly in subsequent studies (cf. chapter 6).

Especially the reductions in smiling behavior may not have been pronounced enough to directly affect the social interactions in this study. As has been recently shown, mimicry of smiling has to be considerably missing to negatively affect social situations (Mauersberger, Blaison, Kafetsios, Kessler, & Hess, 2015). More pronounced reductions in the mimicry of smiles might be expected from people with schizophrenia who exhibit high negative symptoms (tested in study 3). Accurately timing smiles appears to involve anticipating the smiles of the interaction partner throughout an interaction (Heerey & Crossley, 2013). This anticipation requires effortful social cognition such as affect recognition, theory of mind, and affective empathy. All of these are markedly impaired in schizophrenia (Bonfils et al., 2016; Green et al., 2015), indicating an empathic deficit, and most likely reflected in the negative symptoms (Lincoln et al., 2011). The finding that negative symptoms were related to less mimicry of smiles and findings of another study showing that diminished mimicking of nonverbal behavior is related to the negative symptoms in schizophrenia (Kupper et al., 2015) support this view, which will be elaborated more on in chapter 6. Diminished mimicry of pro-social nonverbal behavior thus might represent a behavioral marker for negative symptoms and diminished reflective social cognition. In this understanding, motivational negative symptoms could go along with a lack of effort to anticipate adequate emotional responses (i.e. smiles). Expressive negative symptoms on the other hand may reflect a more generally reduced expressive output that could relate to a trait-like component of negative symptoms (Walther et al., 2015). Considering these distinct processes to account for different portions of the social consequences associated with negative symptoms can also explain why significant inter-correlations were found between smiling synchrony, both negative symptoms domains, and satisfaction with social support.

It is worth noting that the generalizability of findings from healthy samples is limited in terms of understanding clinical samples. Therefore, these findings need confirmation in samples with clinical presentations of schizophrenia (cf. study 3). However, using a non-clinical sample here helped to observe nonverbal correlates of negative symptoms independent of a possible influence of antipsychotic medication. This is particularly important since antipsychotic medication may interfere with the movement-system of potential participants in clinical samples due to extra-pyramidal side effects. Another limitation is that an overestimation of the effect of negative symptoms on the social evaluation could not be completely ruled out because the raters who conducted the CAINS were not blind to the hypotheses. Strengths of the study include the high ecological validity due to the relatively unstructured natural face-to-face interaction and the automatic objective measurement of natural facial expressive behavior with EMG.

In conclusion, motivational and expressive negative symptoms appear to have distinct negative interpersonal consequences even in non-clinical samples. For expressive negative symptoms, these are likely to be relevant to the development of social isolation and negatively affect encounters in the early stages of an acquaintance as well as social support. Overall, study 2 highlights that interpersonal behavior needs to be considered in research on negative symptoms in schizophrenia and might serve as an outcome measure in treatment trials. In this regard, mimicry of smiles may present a behavioral marker for the negative social consequences associated with negative symptoms and with an empathic deficit in schizophrenia.

Chapter 5: Study 3 – The social consequences of aberrant facial expressiveness in schizophrenia: A facial EMG study within a social interaction

5.1. Introduction

As outlined in chapter 1, there is evidence to assume that people with schizophrenia would exhibit diminished levels of emotional facial mimicry and diminished levels of affiliative behavior in face-to-face interaction and that this might explain a lack of rapport others experience with these people. Study 3 will address this research question. Some of the concepts introduced in chapter 1 will therefore be detailed in this section to lead to the specific study hypotheses.

In chapter 1, it had been suggested that interaction partners of people with schizophrenia might often experience a lack of rapport and that this may be related to patients' nonverbal behavior (Grube, 2006; Lavelle, 2011; Raffard et al., 2015; Rümke, 1942). In general, relatively few studies have investigated the social behavior of people with schizophrenia in face-to-face interactions (for a review see Lavelle et al., 2014) even though impairments in social cognition and social skills deficits are thought to play a major role in the disorder (Green et al., 2015). Studies investigating either face-to-face interactions of people with schizophrenia or their responses to emotionally evoking stimuli have shown that emotional facial expressions are reliably reduced in schizophrenia (Kring & Elis, 2013; Kring & Moran, 2008). As presented in chapter 1, studies on face-to-face interactions of people with schizophrenia have shown that patients appear to particularly exhibit diminished levels of pro-social and affiliative behaviors (Blanchard et al., 2015; Brüne et al., 2008, 2009, Troisi et al., 1991, 1998). Interaction partners of people with schizophrenia seem to respond to this diminished expression of pro-social behavior with a down-regulation of their own pro-social behaviors (Krause et al., 1989; Lavelle et al., 2015). Among the emotional facial expressions, smiles are the most obvious affiliative signals (Hess et al., 2000). Thus, smiles can be expected to be lacking in face-to-face interactions of people with schizophrenia, which then should be detrimental to the formation of rapport in these interactions (cf. chapter 1, section 1.4). Furthermore, people with schizophrenia were shown to exhibit difficulties with synchronizing their behavior with their interaction partners and that this was related to negative symptoms (Del-Monte et al., 2013; Kupper et al., 2015; Lavelle, 2011; Raffard et al., 2015; Varlet et al., 2012). The synchronization of emotional facial expressions between interaction partners is what has been defined as emotional mimicry (cf. chapter 3, study 1). Thus emotional facial mimicry could be diminished in schizophrenia, particularly for affiliative expressions (i.e. smiles). Lacking emotional facial mimicry in turn should also be detrimental to the formation of rapport in face-to-face interactions (cf. chapter 1, section 1.4).

Two studies have looked at emotional facial mimicry in schizophrenia so far. The first, (Kring et al., 1999) did not find differences between people with schizophrenia and healthy controls. The second (Varcin et al., 2010) found diminished emotional facial mimicry in schizophrenia in comparison with healthy controls. Both studies investigated participant's facial movements in response to emotional facial expressions presented on a computer screen and assessed these movements with EMG. The major difference between the two studies was the temporal resolution that was used to quantify the mimicry response. Kring and colleagues (1999) averaged Zygomaticus and Corrugator responses, respectively, of their participants for the 7 s following the stimulus presentation. By this Kring and colleagues pursued the common approach in research on behavioral mimicry that looks at whether a behavior is shown more when it is shown more in an interaction partner, however, more or less irrespective of the timing of that behavior (cf. chapter 1, section 1.5). Varcin and colleagues (2010) on the other hand averaged the EMG response for segments of 100 ms each, covering (only) the first 1000 ms after stimulus presentation. A diminished mimicry response for patients compared to controls emerged within the first 500 ms after stimulus presentation.

These results pointed to a difficulty in the timing of the mimicry response (people with schizophrenia responded slower) and underlined the importance of accounting for the timing of the behavioral response when investigating emotional facial mimicry in schizophrenia. As has been shown in chapter 3 (study 1), the timing of the emotional facial mimicry response can be assessed in face-to-face interactions with an analysis method used to quantify interpersonal synchrony.

In chapter 1 it has also been shown that emotional facial mimicry relies on two different processes, one reflexive and one reflective in nature. The reflexive component of emotional facial mimicry was relying on the mirror neuron system and related to the notion that behavior in general is imitated automatically as observed in an interaction partner (Chartrand & Lakin, 2013). In accordance with the study of Kring and colleagues (1999), recent studies have suggested that the mirror neuron system and the reflexive aspect of social cognition may be intact in schizophrenia (Green et al., 2015; Horan, Pineda, Wynn, Iacoboni, & Green, 2014). The reflective component of emotional facial mimicry appears to consist of an anticipation of the emotional facial expressions of the interaction partner (Heerey & Crossley, 2013). Anticipating emotional facial expressions requires an evaluation of the social-emotional context of the interaction and emotional facial mimicry is thought to rely on such an evaluation (Hess & Fischer, 2013). Affect recognition and theory of mind are particularly important in evaluating the socio-emotional context and can be considered reflective social cognitive processes that are impaired in schizophrenia (Green et al., 2015). If these reflective social cognitive processes are impaired in schizophrenia, impairments in the timing of emotional facial mimicry should be a behavioral consequence. The findings of Varcin and colleagues (2010), who found that patients showed diminished mimicry responses in the first 500 ms after stimulus presentation, are in line with these considerations. It appears that particularly the rapid evaluation of socio-emotional context could be impaired in schizophrenia. Accordingly, a deficit in affect recognition might explain diminished emotional facial mimicry in schizophrenia.

Study 3 thus investigated the following hypotheses:

1. Healthy interaction partners experience less rapport with a person with schizophrenia than with another healthy participant. Thus, they evaluate people with schizophrenia less positively than they evaluate healthy controls.
2. People with schizophrenia exhibit less affiliative facial expressions (i.e. smiles and mimicry of smiles) in face-to-face dyadic interactions than healthy controls and comparable levels of non-affiliative facial expressions (i.e. frowns).
3. Diminished affiliative facial expressiveness (less smiles and less emotional facial mimicry) relates to a less positive evaluation by the interaction partner, accounting for the difference between people with schizophrenia and healthy controls.
4. Higher negative symptoms and lower affect recognition relate to less emotional facial mimicry, accounting for the difference between people with schizophrenia and healthy controls.

5.2. Methods

5.2.1. Study design

Hypotheses 1 and 2 predicted differences in the face-to-face interactions and the social evaluations of people with schizophrenia and of healthy controls when interacting with a healthy interaction partner. Thus, interactions of healthy participants with a person with schizophrenia had to be compared with interactions of healthy participants with another healthy participant. In this study, it was therefore opted for a solution in which there was a group of healthy interaction partners (IP) that interacted subsequently with both a person with

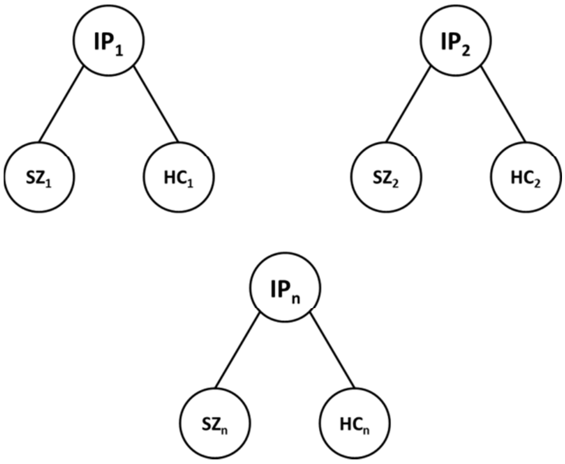


Figure 7. Illustration of the one-with-many-design (cf. Kenny et al., 2006), in which each interaction partner (IP) interacts with one person with schizophrenia (SZ) and one healthy control participant (HC).

schizophrenia (group SZ) and a healthy control participant (group HC). The two participants that IP interacted with were matched so that diagnostic group status (SZ vs. HC) was anticipated to be the single *distinguishing* factor between groups. Study designs in which interactions of one participant with more than one other interaction partner are investigated were referred to as *one-with-many designs* by Kenny and colleagues (2006). Figure 7 illustrates the basic structure of the one-with-many design employed in this study. Note that the small letter index *n* in Figure 7 does not refer to the number of dyads in the study but to the number of one-with-many groups in the study, that is the number of IP-SZ-HC triplets. Each triplet consists of two dyads, IP/SZ and IP/HC. Thus, the total number of dyads observed in the study is $2*n$ and the total sample size is $N = 3*n$. The implications of this study design for the data analysis are presented in section 5.2.5.3.

5.2.2. Sample

A total of 30 IP-SZ-HC triplets were recruited for this sample. That is, 30 people with a diagnosis of schizophrenia or schizo-affective disorder were matched with 30 healthy control participants (group HC) with respect to sex, age, and approximate years of education[11]. These matched pairs of SZ and HC participants then each were assigned to one of 30 IP participants that were of the same sex as the other two participants. Due to technical recording failures of the EMG signal in two of those triplets and incompletion of one HC participant in one more triplet, $n = 27$ IP-SZ-HC triplets were analyzed in the study ($N = 81$). The inclusion criteria for all participants were an age of 18-65, a verbal IQ >80, and no life time diagnosis of any neurological disorder (based on self-report). Participants in the HC and IP groups additionally were required to not have any DSM-IV axis I diagnosis (life time). Participants in the SZ group were required to have a diagnosis of either schizophrenia or schizo-affective disorder. Furthermore, participants in the SZ group were planned to be excluded if they presented too symptomatic to take part in the study (any PANSS positive scale item >5; cf. section 5.2.3.2). In fact, none of the participants that were approached for the study had to be excluded based on this criterion.

Both SZ and healthy participants were recruited via (differing) bulletins posted throughout the greater city area of Hamburg, Germany, as well as via announcements in local online and print media. Because healthy participants should not become aware of the clinical focus of the study (to exclude stigmatization from the interactions), bulletins for SZ and healthy participants, respectively, were never displayed in the same area of the city at the same time. Respondents were then telephone-screened for basic exclusion criteria and eligible participants were invited to take part in the study after they had been assigned to a triplet.

5.2.3. Materials and Instruments

5.2.3.1. Assessments introduced in other sections

Most of the assessments that were used in study 3 have been introduced either in section 3.2 or in section 4.2.2. This includes for the diagnostic assessments the SCID-I used

[11] As will be shown in the results, the matching of years of education was not possible in all cases,

to determine diagnostic status due to DSM-IV, the MWT-B used to assess verbal intelligence (for both cf. section 3.2.1), and the CAINS used to assess negative symptom severity (for these cf. section 4.2.2). For the interaction assessments, this includes the EMG apparatus (cf. section 3.2.4), the SPS/SIAS, SSQ, and the WILL (cf. section 4.2.2). All of these assessments were employed in this study exactly as described in the respective sections. The assessments specific to study 3 will be introduced in the following.

5.2.3.2. Positive and Negative Syndrome Scale (PANSS)

The PANSS (Kay et al., 1987) is a validated observer-rated symptom rating scale that assesses the severity of a total of 30 symptoms associated with psychotic experiencing. The scale is comprised of three subscales, assessing the positive (positive scale; 7 symptoms including hallucinations, delusions) and negative symptoms (negative scale; 7 symptoms including flat affect, passive social withdrawal) as well as general psychopathology (16 symptoms including anxiety, depression). Each symptom is rated based on its severity over the proceeding seven days on a scale ranging from 1 (= "absent") to 7 (= "extreme") according to detailed anchor criteria.

A rater trained by the PANSS institute rated the PANSS for SZ group participants according to information given by the participants in a semi-structured interview. As outlined earlier, scoring higher than 5 (= "moderate severe") on any PANSS positive scale item was an exclusion criterion for the study, since suchlike ratings would refer to positive symptoms that severely interfere with social interactions (such as responding to voices being heard or constantly acting out on delusions).

5.2.3.3. Neuropsychological assessments

Neuropsychological tests were selected based on the recommendations by Exner and Lincoln (2012). The subtest digit span was taken from the Wechsler Adult Intelligence Scales

---

since SZ participants presented with generally lower levels of years of education.

(Wechsler, 1981) to assess attentional capacity. The Trail-Making-Test A and B (TMT-A/B; Reitan, 1992) assessed processing speed (test A) and set shifting speed (test B).

5.2.3.4. Affect Recognition Test (ART)

All participants completed an affect recognition test (ART) as a measure of social cognition. For this, participants had to judge for 28 different facial stimuli, which emotion was being displayed out of a list of seven emotion categories (anger, disgust, fear, happiness, neutral, sadness, and surprise). Photographs of the faces of two male and two female models which displayed these different emotions were chosen from the Radboud Faces Database (Langner et al., 2010), one per model for each emotion category. Thus in the ART, a total of 28 stimuli was presented in random order. The ART was constructed in accordance with the procedures presented by Streit and colleagues (2001), which were used as an outcome measure in treatment trials on affect recognition in schizophrenia (Wölwer et al., 2005; Wölwer & Frommann, 2011).[12] Thus, each trial in the ART started with a fixation cross that was presented in the middle of a computer screen for a time period randomly varying between 1.6 and 2.2 s. The fixation cross was followed by the presentation of a stimulus for 500 ms, then by the presentation of a black screen for 1 s, and finally by the presentation of all seven emotion categories. Participants then had to select what they thought was the correct answer within 8 s. If this time period expired and no answer had been given, the trial was counted as a false response. The outcome was the number of overall correct responses (possible range 0-28). Participants were given the chance to get used to the task in four sample trials for which different models of the same picture set were used that the emotions “disgust”, “fear”, “happiness”, and “neutral” were displayed in a random order.

5.2.3.5. Self-Assessment Manikins

The Self-Assessment Manikins (SAMs; Bradley & Lang, 1994) were used to monitor of participants' mood to be able to react in the case of adverse events (severe drop of mood or increase of unpleasant arousal). Participants thus indicated on two scales from 1 to 9 whether their mood was rather positive or negative (valence dimension) and whether they felt rather low or high arousal (arousal dimension). This mood monitoring was obtained once upon arrival, once directly before the beginning of the face-to-face interaction and directly after the interaction. The corresponding results are presented in Appendix D. For the vast majority of the participants (patient and controls) mood did either not change or got better after the interaction.

5.2.4. Procedures

SZ and HC participants completed two assessment days in the study and IP participants completed three assessment days. First, all participants completed the SCID, the neuropsychological assessments, the ART, the PANSS (SZ group only), and the CAINS in an assessment session that lasted for about 1.5 h for healthy participants (HC and IP groups) and about 3h for SZ participants.[13] Participants were presented with the same cover story as in studies 1 and 2 (cf. section 3.2.3).

The interactions then were carried out on another day. Since IP participants were interacting with both SZ and HC participants, respectively, IP participants completed two interaction assessments on two separate days. The second interaction assessment for IP differed from the first one only in that the SPS/SIAS and SSQ were not part of the assessment, that another unknown person was the interaction partner, and that they were instructed to talk about the same events as they did in the first interaction. Whether IP participants first interacted with a participant from the SZ or the HC group was roughly

[12] Streit et al. (2001) and Wölwer et al. (2005, 2011) had not included a „neutral" category and thus had included 24 facial stimuli.

counterbalanced across all IP participants.[14] The interaction protocol was employed exactly as in studies 1 and 2 (cf. section 3.2.3). That is, after a warm up phase, positive and negative life events were discussed, which then was followed by a cool down period. Positive and negative events were blocked and the order of the valence blocks was counterbalanced within the SZ and HC groups. Table 5 shows how the study cases were assigned to the two counterbalancing procedures.[15]

The SPS/SIAS and the SSQ were completed before the interactions. EMG was measured continuously throughout the interactions, as presented in studies 1 and 2. Accordingly, activity was captured from the Zygomaticus (smiling) and Corrugator (frowning) muscles. The participants evaluated each other with the WILL after the interactions. During the debriefing, healthy participants were informed that people with

Table 5.

Distribution of the study cases across counterbalanced variables

Dyad	First or second interaction?	Which event first? Positive	Negative	Total
IP/SZ	First	8	4	12
	Second	6	9	15
	Total	14	13	27
IP/HC	First	7	8	15
	Second	7	5	12
	Total	14	13	27

Note: IP = group of interaction partners; SZ = group of people with schizophrenia; HC = group of matched healthy controls.

[13] Assessment of SCID-I diagnoses and the PANSS accounted for the difference in duration.
[14] The sample was not ideally counterbalanced with respect to this variable due to scheduling difficulties with the participants.
[15] Counterbalancing of valence blocks was only performed within the SZ and HC groups, respectively, but not in combination with the counterbalancing of whom the IP interacted with first, which resulted in the pattern shown in Table 5.

mental disorders would also take part in the study but that due to data privacy it could not be disclosed whether or not they actually had encountered a participant with a mental disorder.

5.2.5. Data analysis

5.2.5.1. Quantification of facial expressions via EMG

The same approach as has been delineated in section 4.2.4.2 was used in this study. Thus, a single score for the overall activation of the Zygomaticus (smiling) muscle and for the Corrugator (frowning) muscle per participant per dyad was obtained.

5.2.5.2. Quantification of emotional facial mimicry

The same approach as has been delineated in section 4.2.4.3 was employed in this study. Thus, a single score for the overall mimicry of Zygomaticus (smiling) activity per participant per dyad was obtained.

5.2.5.3. Handling of the dyadic data structure and hypothesis testing

As outlined in section 5.2.1, the design of the study can be labelled a "one-with-many design" (Kenny et al., 2006) because IP participants (the "one") interacted with two different participants (the "many"), one from each group (SZ and HC). In accordance with Kenny and colleagues, the IP may be labelled the *focal person* in the design, who is bound to two *partners*. The partners in the design of this study are *distinguishable* by their group status (SZ vs. HC). There is *non-independence* (cf. section 4.2.4.1) because of variance which is due to the IP. Thus, if the difference between SZ and HC participants was of interest, the data could be analyzed using paired samples t-tests, comparing the scores obtained from IP/SZ and matching IP/HC dyads. Hypotheses 1 and 2 were thus tested with paired samples t-tests. Separate tests were calculated for the WILL scores given by IP participants targeting either SZ or HC, for the Zygomaticus (smiling) activity, for the Zygomaticus (smiling) mimicry, and for the Corrugator (frowning) activity.

Hypotheses 3 and 4 stated that the affect recognition of SZ and HC participants would relate to their smiling behavior and that smiling behavior in turn would relate to the IP's social evaluation. Thus, variables measured at the dyad-level in this study (e.g. SZ's affect recognition), were the predictors of the social outcomes. If covariates are to be included in the analysis, the scores for SZ and matching HC participants could be compared in a repeated measures ANCOVA where IP/SZ vs. IP/HC dyad is a repeated measures factor. However, in an ANCOVA, covariates can only be modelled when IP-SZ-HC triplet is the unit of observation (e.g. IP's age). According to Kenny and colleagues (2006), if covariates are to be included for the distinguishable partners in the one-with-many design (e.g. SZ's and HC's affect recognition), the data may be best analyzed using structural equation modelling (SEM). In an SEM modelling a one-with-many-design, "there is a latent variable that causes the score for each partner. The variance due to the focal person is contained in this latent variable" (Kenny et al., 2006, p. 287). In this study, a latent IP variable was thus used to model the non-independence in the data when testing hypotheses 3 and 4. The two partners (SZ and HC) were the indicator variables of this latent variable. The hypotheses of this study allowed for a theory-driven model specification in which the smiling behavior (Zygomaticus activity and Zygomaticus mimicry exhibited by SZ or HC participants, respectively) predicted the social evaluation by IP participants (WILL of IP targeted on SZ/HC) after the interaction. Moreover, the smiling behavior of a person was assumed to be influenced by the social cognition (affect recognition) of this person. The two basic SEM models that were specified to test these hypotheses in the one-with-many-design of this study are illustrated in Figures 8 and 9. In each model, two parameter estimates were tested for significance. In the model in Figure 8, the influence of social cognition (affect recognition) on Zygomaticus (smiling) mimicry was tested for SZ and HC, respectively. In accordance with the suggestions in Kenny and colleagues (2006), equal factor loadings were presumed for the connections of the latent IP variable with the indicator variables. In the model in Figure 9 the influence of smiling behavior on the IP's evaluation with the WILL was tested for SZ and HC, respectively. Again,

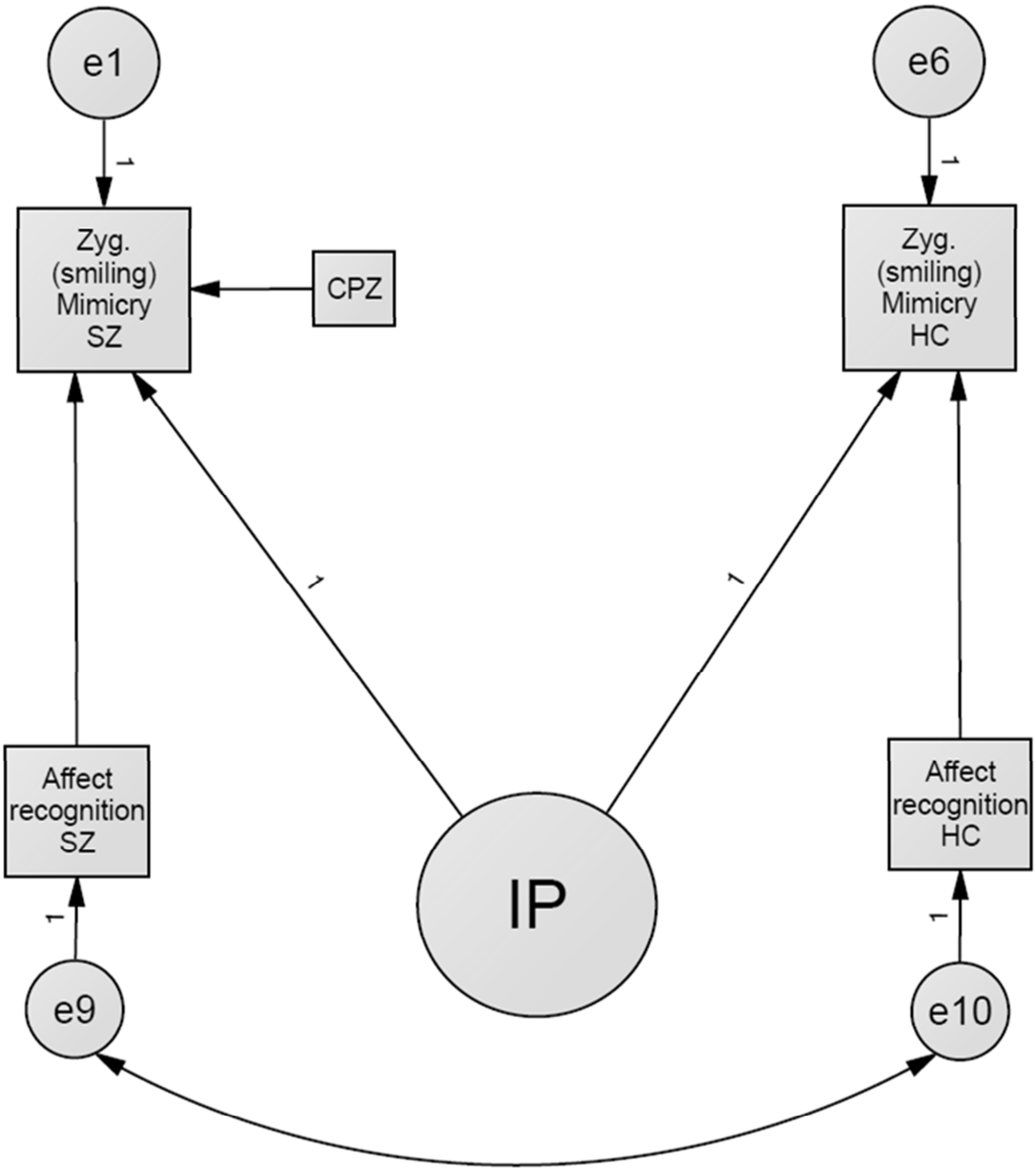


Figure 8. SEM model for the estimation of the influence of affect recognition as assessed with the ART on Zygomaticus (smiling) mimicry of people with schizophrenia (SZ) and healthy controls (HC), while controlling for the common influence of the interaction partner (IP). Zygomaticus (smiling) mimicry in SZ participants is controlled for medication (CPZ = Chlorpromazine equivalent dose).

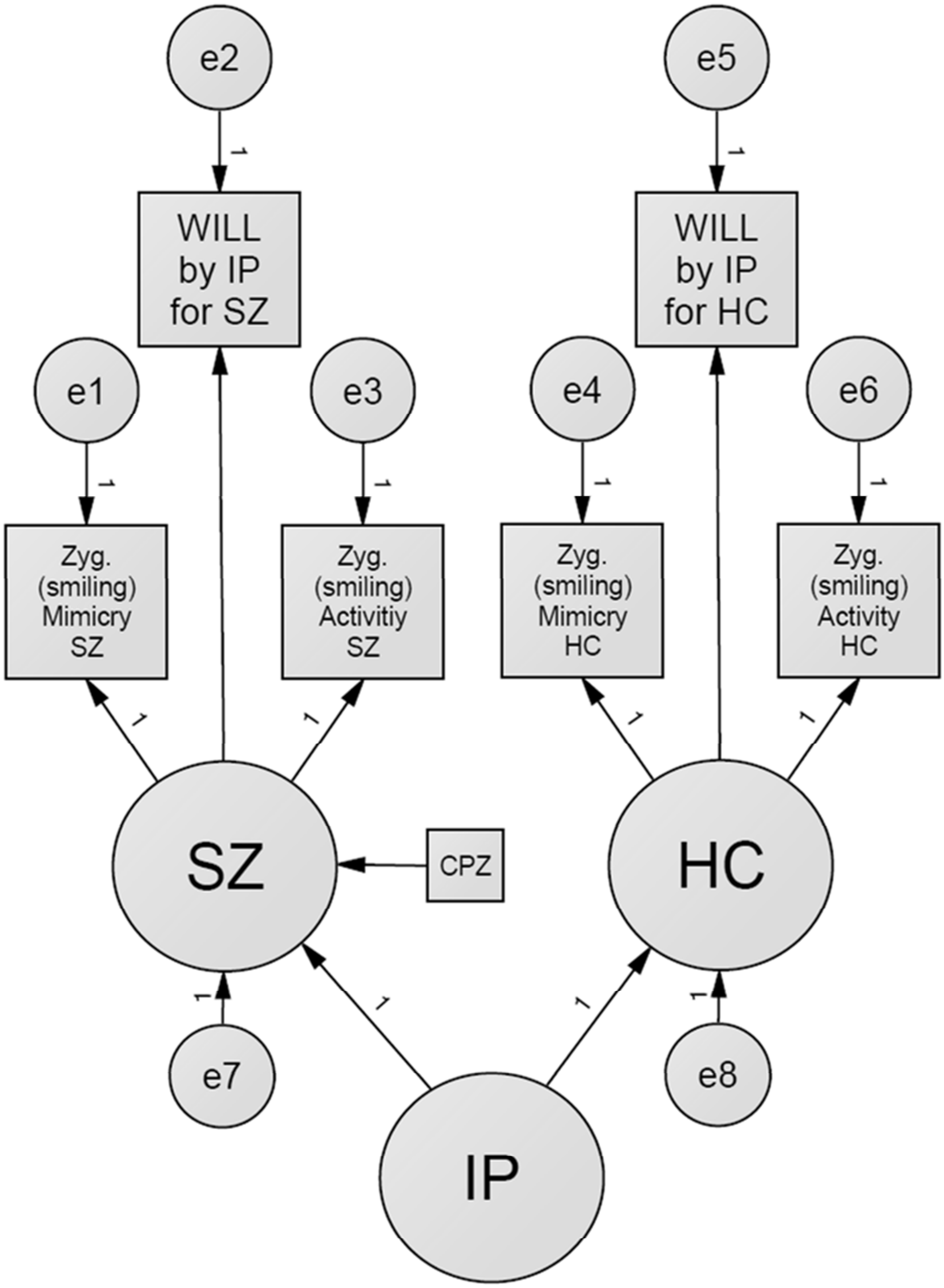


Figure 9. SEM model for the estimation of the influence of Zygomaticus (smiling) activity and mimicry on the Willingness-to-interact scale (WILL) scores by the interaction partners (IP) for people with schizophrenia (SZ) and healthy controls (HC), respectively. Smiling behavior in SZ participants is controlled for medication (CPZ = Chlorpromazine equivalent dose).

equal factor loadings were presumed for the indicator variables of the latent IP variable. Additionally, equal factor loadings were presumed for both indicator variables of the SZ/HC latent variable that measured smiling behavior to be able to measure their combined influence on the WILL scores given by IP participants. Note, that in both models, SZ's medication was included as a covariate using chlorpromazine (CPZ) equivalents (mg/day) according to Woods (2003, 2005) to control for possible motor abnormalities due to antipsychotic medication. The analyses were run using IBM SPSS Amos 22. For all models, common fit indices (χ^2-test, Comparative Fit Index [CFI], Root Mean Square Error of Approximation [RMSEA]) were examined to check for the reliability of the estimated parameters. All parameters were expressed as standardized β-weights and tested at an α-level of $p = .05$.

5.3. Results

5.3.1. Sample characteristics

Of the 27 analyzed IP-SZ-HC triplets, 15 were all female and 12 were all male participants (55.6% female). All other sample characteristics are presented in Table 6 for IP participants and in Table 7 for SZ and HC participants. As can be seen in Table 7, within triplets, SZ and HC participants did not differ with respect to age and verbal IQ (MWT-B), but differed significantly in years of education. Thus the matching of the SZ and HC participants appeared to be fairly appropriate. Concerning neuropsychological tests, SZ participants performed poorer than their HC matches in the TMT A (slower responses) and the digit span, and not significantly poorer in the TMT B. Furthermore, SZ participants reported significantly higher social anxiety in the SPS and SIAS. No differences were found concerning social network size and satisfaction with the social support network. SZ participants also did not perform significantly poorer in affect recognition than HC

Table 6.

Sample characteristics for IP participants.

	M	SD
Age	40.1	13.9
Years of education	16.3	3.85
MWT-B	29.9	3.29
TMT A	26.2	8.61
TMT B	61.4	17.5
Digit span	6.74	1.23
SPS	6.85	3.78
SIAS	15.3	7.68
SSQ network size	7.26	3.49
SSQ network satisfaciton	19.5	4.26
ART overall correct	20.3	3.66
CAINS-MAP	5.44	4.66
CAINS-EXP	1.89	2.15

Note: MWT-B = Mehrfachwahl Wortschatztest, raw score; TMT A/B = Trail Making Test A/B; SPS = Social Phobia Scale; SIAS = Social Interaction Anxiety Scale; SSQ = Social support questionnaire; SSQ network size = number of different people named; ART = affect recognition test; CAINS-MAP/EXP = Clinical Assessment Scale for Negative Symptoms Motivation and Pleasure/Expressiveness Scale.

participants, but endorsed higher negative symptoms on both CAINS-MAP and CAINS-EXP. All but two SZ participants took antipsychotic medication.

5.3.1. Conversational content

SZ and HC participants did not differ with respect to the self-reported intensity of the events (i.e. how joyful/annoying the event was for them). The intensities were generally rated high on the 1-to-9 scaled items by both SZ (positive: M = 7.9, SD = 1.1; negative: M = 6.6; SD = 2.1) and HC participants (positive: M = 7.7, SD = 1.4; negative: M = 6.9; SD = 1.6). The experimenters noted that in two of the IP/SZ dyads, the SZ participant somewhat revealed a patient status. One SZ participant chose for both the positive and the negative

Table 7.

Sample characteristics and difference tests for SZ and HC participants.

	SZ		HC		Cohen's d_z (SZ>HC)
	M	SD	M	SD	
Age	41.7	10.9	43.1	12.3	-0.25
Years of education	15.1	3.58	17.8	3.95	-0.62 **
MWT-B	28.9	3.93	30.2	3.84	-0.25
TMT A	31.0	11.7	24.9	9.55	0.47 *
TMT B	76.6	37.9	63.7	24.0	0.26
Digit span	6.78	1.01	7.52	1.28	-0.40 *
SPS	18.3	11.1	8.92	6.96	0.74 **
SIAS	25.1	10.8	14.8	8.10	0.98 ***
SSQ network size	7.13	3.79	6.48	2.50	0.04
SSQ network satisfaciton	20.5	2.32	21.0	2.30	-0.23
ART overall correct	19.6	4.68	21.3	3.48	-0.27
CAINS-MAP	12.2	6.32	5.48	4.72	0.78 ***
CAINS-EXP	3.22	2.76	1.78	1.83	0.45 *
PANSS positive	16.4	6.66			
PANSS negative	13.2	4.19			
PANSS general	33.8	9.06			
Years since first diagnosis	14.6	10.6			
CPZ	475.1	662.6			

Note: MWT-B = Mehrfachwahl Wortschatztest, raw score; TMT A/B = Trail Making Test A/B; SPS = Social Phobia Scale; SIAS = Social Interaction Anxiety Scale; SSQ = Social support questionnaire; SSQ network size = number of different people named; ART = affect recognition test; CAINS-MAP/EXP = Clinical Assessment Scale for Negative Symptoms Motivation and Pleasure/Expressiveness Scale; PANSS = Positive and Negative Syndrome Scale; CPZ = chlorpromazine equivalents. Cohen's *d* effect sizes and significance values refer to paired samples t-tests between matched SZ/HC pairs.
* $p < .05$
** $p < .01$
*** $p < .001$

event delusional experiences and another SZ participant in the unstructured warm up phase talked about receiving a "depot medication in the psychiatry". These cases were not excluded from the general analyses, since they did not particularly refer to schizophrenia or psychosis.

Yet, all hypothesis tests were additionally performed excluding these cases and the results are reported in Appendix D.

5.3.2. Differences in facial expressive behavior and social evaluation

In support of hypothesis 1, IP participants evaluated SZ participants significantly less positive on the WILL than the matched HC participants ($t(26) = -4.04$; $p = .005$; $d_z = -0.59$). Contrary to hypotheses 2, however, there were no significant differences between matched SZ and HC participants in terms of facial expressive behavior. SZ participants did not activate their Zygomaticus (smiling) muscle ($t(26) = -0.84$; $p = .41$; $d_z = -.16$) or their Corrugator (frowning) muscle ($t(26) = -1.33$; $p = .20$; $d_z = -0.18$) significantly less than HC participants. SZ and HC participants also appeared to exhibit comparable levels of smiling mimicry ($t(26) = -1.08$; $p = .29$; $d_z = -0.21$). All effects were in the negative direction (SZ scoring lower on the descriptive mean) and small in size.

5.3.3. Affect recognition and Zygomaticus (smiling) mimicry

Figure 10 shows the estimated SEM for the relationship of affect recognition as assessed with the ART and Zygomaticus (smiling) mimicry. The model provided fairly acceptable fit indices ($\chi^2(5) = 5.20$, $p = .39$; CFI = .95; RMSEA = .04) suggesting sufficient reliability of the single parameter estimations. As can be seen in Figure 10, affect recognition predicted Zygomaticus (smiling) mimicry significantly in the HC ($\beta = .54$; $p < .001$) but not in the SZ group ($\beta = .17$; $p = .38$). Thus, only in the HC group, a better ability to recognize emotional facial expressions in the ART was associated with more smiling mimicry in the interactions. SZ's medication (CPZ) did not have a significant influence on SZ's Zygomaticus (smiling) mimicry ($\beta = -.15$; $p = .46$). Variance due to the IP (IP latent variable) in combination with HC's affect recognition explained 44% of the variance in Zygomaticus (smiling) mimicry in HC participants. The variance due to the IP (IP latent variable) in combination with HC's affect recognition in additional combination with SZ's medication explained 28% of the variance in Zygomaticus (smiling) mimicry in SZ participants. Thus it appears that, in healthy participants, affect recognition shaped the mimicry behavior above and beyond the influence of the IP participant on the interaction, whereas in SZ participants this was not the case.

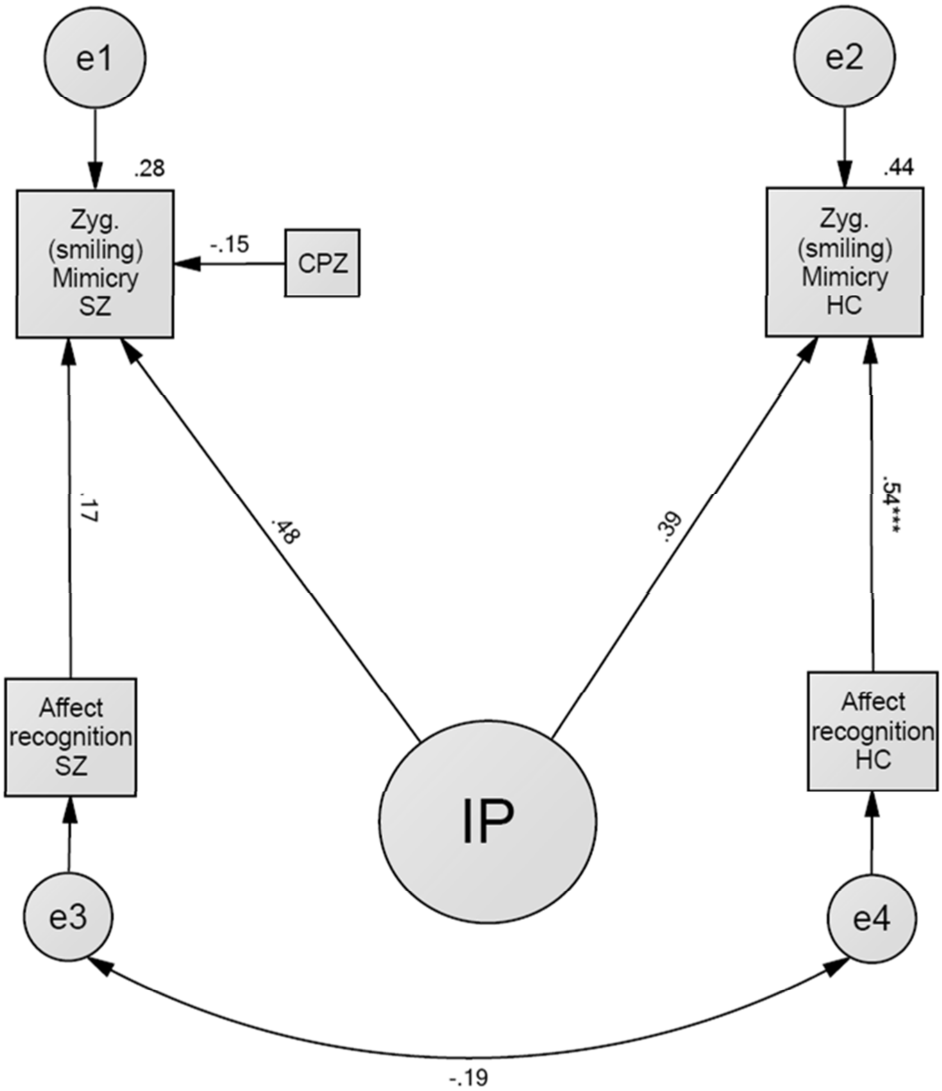


Figure 10. Estimated SEM model for the influence of affect recognition on Zygomaticus (smiling) mimicry for people with schizophrenia (SZ) and healthy controls (HC), while controlling for the common influence due to the interaction partner (IP).
Model fit: $\chi^2(5) = 5.20$, $p = .392$; CFI = .95; RMSEA = .04.
*** $p < .001$.

5.3.4. Social evaluation and smiling behavior

Figure 11 illustrates the estimated SEM for the relationship of SZ's and HC's smiling behavior (Zygomaticus activity and mimicry) with the social evaluation of the IP participants. In this model, latent variables represent the smiling behavior of SZ and HC participants. These latent variables were used to predict the social evaluations by IP participants. For SZ participants, CPZ is included as a covariate and a common IP factor is used to account for the non-independence. The model perfectly fit the data ($\chi^2(15) = 10.61$, $p = .779$; CFI = 1.0; RMSEA = 0.0) suggesting sufficient reliability of single parameter estimations. SZ's medication did not have a significant impact on the latent SZ variable that was comprised of smiling behavior and the social evaluation ($\beta = -.34$; $p = .135$). That is, higher doses of antipsychotic medication did not significantly influence smiling behavior and the WILL scores negatively. Nevertheless, the combination of the latent IP factor and CPZ explained 65% of the variance in the latent SZ variable, suggesting that the latent IP factor explained a significant portion of this variance. The latent IP factor alone explained 65% percent of the variance in the HC latent variable. Thus, in combination with the overall good model fit, capturing the variance due to the IP in the latent IP variable appeared to represent the data well. Also, the IP participants seemed to contribute to both interactions in a similar way, as indicated by positive high factor loadings for both the SZ and the HC latent variable. Smiling behavior comprised of Zygomaticus (smiling) activity and mimicry predicted the social evaluations by the IP significantly in the SZ group ($\beta = .84$; $p = .008$) and marginally on trend-level in the HC group ($\beta = .55$; $p = .10$). More smiling behavior was thus associated with a more positive evaluation by the interaction partner after the interaction particularly for SZ participants. For SZ participants, smiling behavior explained 71% of the variance in the social evaluations by the IP, whereas for HC participants, 30% of the variance in the IP's

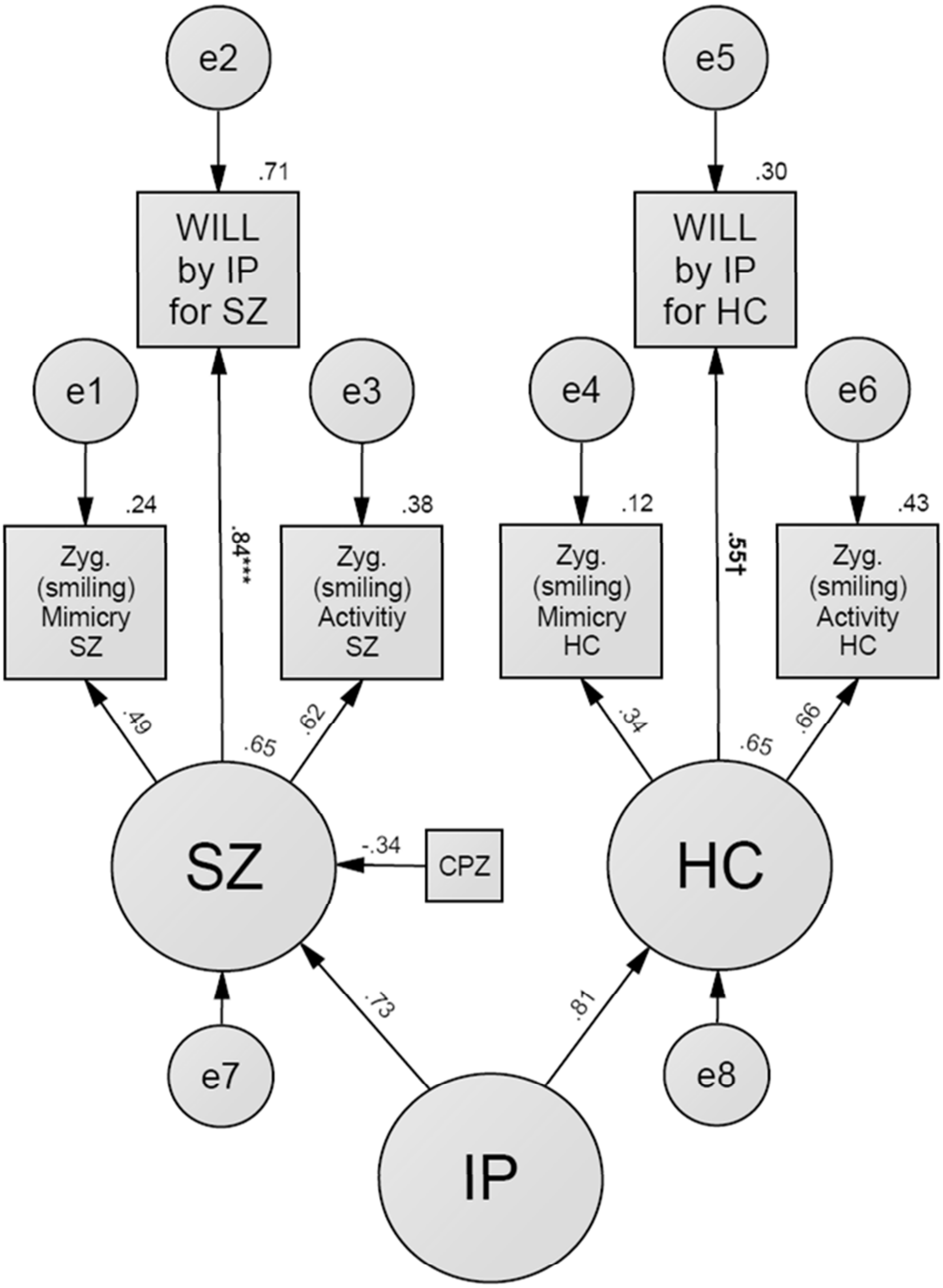


Figure 11. Estimated SEM model for the influence of smiling behavior on Willingness-to-interact scale (WILL) scores given by the interaction partners (IP) for people with schizophrenia (SZ) and healthy controls (HC).
Model fit: $\chi^2(15) = 10.61$, $p = .78$; CFI = 1.0; RMSEA = 0.0.
† $p < .10$; *** $p < .001$.

WILL scores was explained by smiling behavior. Thus, the IP participants seemingly based their social evaluations heavily on the smiling behavior when interacting with SZ participants, more so, than when interacting with another healthy participant. Examining the critical ratio difference of the intercepts for the IP's WILL scores for SZ and HC, respectively, revealed that the WILL scores were lower for SZ than for HC participants on trend-level (z = -1.73; p = .08). This difference test is analogue to a paired-samples t-test (cf. section 5.3.3) that controls for the influence of the covariates in the model (here: smiling behavior).[16] These results suggest that, not only the IP's social evaluation of SZ participants relied on SZ's smiling behavior, but moreover that the difference between the social evaluations of SZ and HC participants was substantially accounted for by corresponding differences in smiling behavior.

5.3.5. Additional analyses: Bivariate relationships

Bivariate relationships of all obtained variables with the social outcomes (WILL, Zygomaticus activity, Zygomaticus mimicry) were calculated as exploratory analyses. For this, the SEM model in Figure 8 was modified so that the covariate (affect recognition in the figure) predicted a social outcome. The resulting β-weights are presented in Table 8. That this analysis is analogous to the one presented in section 5.3.4 can be seen when examining the results for the influence of affect recognition on Zygomaticus (smiling) mimicry. As can be seen in Table 8, also on the bivariate level, smiling behavior was significantly associated with the IP's social evaluation in SZ participants. Zygomaticus (smiling) mimicry was also related to the IP's social evaluation in HC participants. Higher age was related to lower levels of Zygomaticus activity in HC participants. In HC participants, negative symptoms assessed with the CAINS were related to lower Zygomaticus mimicry. In SZ participants, negative symptoms assessed with the PANSS (but not with the CAINS) were related to less

[16] When setting up a comparison model that does not include smiling behavior, this difference test in

Zygomaticus activity. Neither patients' depression nor their medication significantly impacted any of the social outcomes.

5.4. Discussion

Study 3 examined whether people with schizophrenia would be evaluated less positively by their interaction partners as a result of a lack of affiliative facial expressiveness and diminished social cognition. For this, emotional facial expressions (smiles and frowns) were captured via EMG in natural face-to-face interactions of people with schizophrenia and healthy interaction partners. Affiliative facial expressiveness was operationalized as the amount of smiles and the amount of reciprocated smiles (smiling mimicry) exhibited in the interactions. The results showed that indeed, healthy interaction partners indicated less willingness for future interactions with people with schizophrenia than with healthy controls. These interaction partners based their judgments on the smiling behavior of SZ participants so that more smiling behavior led to more positive evaluations. However, there was no genuine reduction in affiliative facial expressiveness in people with schizophrenia. Mimicry of smiling in healthy participants but not in participants with schizophrenia was explained by the ability to recognize emotional facial expressions (affect recognition).

Less willingness for future interactions with people with schizophrenia than with matched healthy controls was expressed by the interaction partners by a large effect size (d_z = -0.59). That this effect emerged despite the fact that the evaluating interaction partners were unaware of the patient status of their counterparts strongly suggests that aberrant social behavior was the leading cause in these judgments. This is in line with a study by Penn and colleagues (2000), who had shown that the social distance desired towards people with schizophrenia was related to how "strange" their behavior was evaluated by independent

fact yields a significant result (z = 3.08; p = .002), resembling the result of the paired samples t-test in section 5.3.3.

Table 8.

Regression coefficients (β-weights) for bivariate regressions on the social outcomes, accounting for non-independence due to IP.

	SZ			HC		
	WILL by IP	Zyg. Activity	Zyg. Mimicry	WILL by IP	Zyg. Activity	Zyg. Mimicry
Age	-.10	-.04	-.16	-.27	**-.59** ***	-.44*
Years of education	.10	.22	-.01	.29	-.22	-.09
MWT-B	.09	-.11	.18	-.24	-.32 †	-.20
TMT A	-.22	-.08	-.22	-.04	-.15	-.33†
TMT B	-.16	-.16	-.25	.04	-.07	-.44*
Digit span	.26	.10	.10	.15	.05	.42*
SPS	-.34 †	-.26	.01	-.31 †	.00	.04
SIAS	-.31 †	-.16	.23	-.17	.13	.10
SSQ network size	.26	.24	.10	.19	.35 †	.16
SSQ network satisfaciton	-.03	.26	.15	-.11	.37 †	.09
ART overall correct	.33 †	.18	.17	.25	.35 †	**.54*****
Zyg. Activity	.52 **	-	.38 *	.32 †	**-**	.18
Zyg. Mimicry	.40 *	- [b]	-	.39 *	- [b]	-
CAINS-MAP	-.05	-.13	.24	-.25	-.24	-.48**
CAINS-EXP	-.09	-.30	-.30 †	-.30 †	-.07	-.43**
PANSS positive	-.18	-.15	.08			
PANSS negative	-.25	-.46 **	-.28			
PANSS general	-.24	-.09	-.03			
PANSS item G6 Depression	-.11	-.02	.06			

Table 8 continued.

	SZ			HC		
	WILL by IP	Zyg. Activity	Zyg. Mimicry	WILL by IP	Zyg. Activity	Zyg. Mimicry
Years since first diagnosis [a]	.46 †	.06	.26			
CPZ	-.31 †	-.13	-.20			

Note: WILL = Willingness-to-interact scale; Zyg. = Zygomaticus; MWT-B = Mehrfachwahl Wortschatztest, raw score; TMT A/B = Trail Making Test A/B; SPS = Social Phobia Scale; SIAS = Social Interaction Anxiety Scale; SSQ = Social support questionnaire; SSQ network size = number of different people named; ART = affect recognition test; CAINS-MAP/EXP = Clinical Assessment Scale for Negative Symptoms Motivation and Pleasure/Expressiveness Scale; PANSS = Positive and Negative Syndrome Scale; CPZ = Chlorpromazine equivalents. Bold coefficients remained significant after Bonferroni correction.

[a] additionally controlled for age

[b] not calculated due to redundancy

† $p < .10$

* $p < .05$

** $p < .01$

*** $p < .001$

raters. In Penn and colleagues (2000), the judges also were healthy people, but watched video tapes of people with schizophrenia interacting in role play scenes rather than interacting with the patients themselves. Also, in Penn and colleagues there was no healthy control group. This is the first study to have shown a rejection of people with schizophrenia compared to healthy controls by everyday interaction partners after a face-to-face conversation. Other studies in the field have looked at feelings of connectedness towards people with schizophrenia, but did not include actual conversation in their study (Raffard et al., 2015), have looked at the ratings of clinicians (Lavelle et al., 2015; Riehle et al., 2015), or failed to show a similar effect, possibly due to employing three-way-interactions rather than dyadic interactions (Lavelle et al., 2013). Being rejected, when first encountering a new acquaintance, prevents people with schizophrenia from establishing new friendships. The rejection thus contributes to exclusion by the social environment and feelings of loneliness.

The driving aspect for low social evaluations of people with schizophrenia in this study was a low level of smiling behavior (amount of smiling and mimicry of smiles). The smiling behavior explained 71% of the variance of the social evaluations of people with schizophrenia and no other measure obtained in this study showed a significant relationship with the social evaluations. This is in line with other studies that have shown that reductions in the social behavior of people with schizophrenia is related to a less positive social evaluation (Lavelle et al., 2013; Raffard et al., 2015; Riehle et al., 2015). However, in this study, there was no significant difference in the smiling behavior between people with schizophrenia and healthy controls, neither for the amount of smiling (Zygomaticus activation) nor for the mimicry of smiles (Zygomaticus mimicry). Smiling behavior thus could be a proxy for a more global aberration of affiliative behavior in schizophrenia. A global reduction of affiliative behavior has also been suggested by other authors (Blanchard et al., 2015; Hooley, 2010). The reduction in smiling behavior thus could go along with other nonverbal reductions found in schizophrenia, such as nodding and head movements in general (Kupper et al., 2015; Lavelle et al., 2013), gesturing (Walther & Mittal, 2016), or prosody (Cohen et al., 2008). For all of these nonverbal domains, computerized assessments have been developed and they thus could be investigated conjointly in subsequent studies. The finding that in healthy participants the relationship between smiling behavior and the social evaluation was weaker supports the notion of a more global behavioral aberration in schizophrenia. Healthy controls might have compensated for lacking affiliative facial expressions with affiliation expressed through the other nonverbal channels just mentioned.

Assuming that people with schizophrenia are not able to compensate for lacking affiliative facial expressions suggests that also a more global social cognitive deficit underlies the social behavioral difficulties. An empathic deficit has been suggested for schizophrenia that involves affect recognition, theory of mind, and affect sharing (Bonfils et al., 2016; Green et al., 2015). In this study, affect recognition of facial expressions was assessed as a measure of this empathic deficit. Despite other studies showing that people with schizophrenia perform poorly on this test (e.g. Streit et al., 2001), people with schizophrenia in this study did not.[17] Also contrary to the hypotheses of this study, facial affect recognition was unrelated to mimicry of smiles in people with schizophrenia. It was, however, related to the mimicry of smiles in healthy controls, suggesting that the basic mechanism is traceable. Thus, empathy, as a more global construct, may be comprised of affect recognition, theory of mind, and affect sharing, but affect recognition might not have been impaired in this sample, whereas the other domains could have been impaired, but were not assessed. One would then expect that assessments of theory of mind and affect sharing (e.g. emotional mimicry) would

[17] Comparing the data of this study to the data of the study of Streit and colleagues (2001), whose affect recognition test was adopted for this study, yielded that both people with schizophrenia and healthy controls performed better on the task in this study. One difference between the two assessments was that Streit and colleagues used Ekmans Pictures of Facial Affect (Ekman & Friesen, 1975), whereas this study used a more recent picture system (Langner et al., 2010), so that better performance could be due to higher quality and clarity of expressions in the more recent picture set.

not be related to affect recognition. On the other hand, when empathy is intact (as in healthy controls), affect recognition should be correlated with other measures of empathy and thus with emotional mimicry, as was the case in this study.

It is worth noting, however, that several other studies in schizophrenia have found both reductions in the amount of smiling expressed (for reviews see Kring & Elis, 2013; Kring & Moran, 2008) and the behavioral mimicry of other people (e.g. Lavelle, 2011; Varlet et al., 2012). One reason for this could be a lack of power to detect the possibly small to medium sized effects that were traceable for the reduction in smiling behavior also in this study. Due to the cumbersome assessment of dyadic interactions, to ensure the feasibility of the study, a relatively small sample had to be obtained. However, most other studies in the field have recruited comparably sized (Kupper et al., 2015) or even smaller patient samples (Krause et al., 1989; Lavelle et al., 2013) and the hypothesized effects could generally be detected in either the patient or the control group. Moreover, whereas this study was particularly aimed at achieving a high ecological validity, other studies might have achieved higher internal validity and thus could control measurement errors to a greater extend (e.g. Blanchard et al., 2015; Kring et al., 1999; Varcin et al., 2010).

Another aspect that limits the generalizability of the results is that the people with schizophrenia in this study presented with rather low levels of negative symptoms. Negative symptoms have been shown to relate to the behavioral phenomena studied in this dissertation (Blanchard et al., 2015; Kring & Elis, 2013; Kupper et al., 2015; Lavelle et al., 2014). Particularly the convenience sampling of people with schizophrenia from the community might have attracted people with schizophrenia who more interested in social interactions and less symptomatic. In addition to the constraints mentioned in the previous paragraph, this might explain the generally small effects for differences in smiling behavior. Nevertheless, the symptom profile of this study's sample matched the symptom profile found for people with schizophrenia who displayed particularly low pro-social behavior (Lavelle et al., 2015) which might explain why there still was a large effect on the social evaluation in this study.

Particular strengths of this study were that the ecological validity was higher than in any study on facial expressions in schizophrenia assessed via EMG (e.g. Kring et al., 1999; Varcin et al., 2010), as mentioned above, with the trade-off that the internal validity was lower than in those studies. Nevertheless, the automatic assessment of facial expressions via EMG was less prone to measurement error than if videos had been coded by human coders (e.g. Krause et al., 1989) and allowed for the application of windowed cross-lagged correlation to analyze facial mimicry. Thus the objectivity was higher than in studies using coding procedures of facial expressions. Moreover, in comparison to other studies that have taken the perspective of the interaction partner into account (e.g. Lavelle et al., 2015, 2013; Raffard et al., 2015), this study employed a stricter control condition by directly comparing the interactions of a single interaction partner with a person with schizophrenia and with a matched healthy control person (the one-with-many design). The closest approximation to this control condition so far was employed by Raffard and colleagues (2015) who matched their healthy controls with their patient sample. However, patients and healthy controls then interacted with different interaction partners. Thus, the internal validity of this study was higher than in other studies on the perspective of interaction partners of people with schizophrenia.

In conclusion, the findings of study 3 suggest that social rejection of people with schizophrenia happens even in the absence of a stigmatizing diagnosis label. This rejection can be reliably attributed to aberrant affiliative behavior, for which reductions in smiling behavior appear to present a viable proxy. This aberration may be representative of an social cognitive empathic deficit in schizophrenia that prevents the affected person from appropriately responding to the emotional expressions of their interaction partner. This mechanism may explain how, apart from social withdrawal tendencies and labelled stigmatization, people with schizophrenia become isolated in the social environment. Because both the empathic deficit and the behavioral aberration, which constitute this mechanism, might be multidimensional constructs, future studies need to assess the various components conjointly. Studies are available for various single components and study 3 now narrowed the research gap for facial expressions.

Chapter 6: General Discussion

6.1. Summary

The aim of the three studies presented in this dissertation was to test the assumption that diminished affiliative facial expressiveness in schizophrenia has negative interpersonal consequences. For this, affiliative facial expressiveness was operationalized as the amount of smiling and the mimicry of smiling in face-to-face first encounters that were assessed via EMG. Study 1 showed that emotional facial mimicry can be reliably quantified using a time-series analysis approach. It also showed that affiliative facial expressions (smiles) were mimicked by the interaction partner whereas non-affiliative facial expressions (frowns) were rare in occurrence and not mimicked. Study 2 showed in healthy participants that particularly expressive negative symptoms related to negative interpersonal consequences and that motivational negative symptoms related to diminished smiling behavior. However, diminished smiling behavior did not have negative interpersonal consequences in this study. Finally, study 3 showed that people with schizophrenia are readily rejected based on their diminished smiling behavior. Additionally, study 3 suggested a global reduction in affiliative nonverbal behaviors in schizophrenia and an empathic deficit as the underlying cognitive construct.

6.2. Global reduction in affiliative nonverbal behavior and the empathic deficit in schizophrenia

Both studies 2 and 3 suggested that smiling behavior may be a proxy for a more global reduction in affiliative nonverbal behavior. In study 3, interaction partners appeared to base their judgments on smiling behavior and indicated lower levels of willingness for future interactions with people who smiled less. However, this association was particularly pronounced for people with schizophrenia and only on a trend-level significant basis in healthy controls. The difference in the strength of the associations between patients and controls might signify that healthy participants were able to compensate for lacking smiling behavior whereas patients were not. In study 2, healthy participants' expressive negative symptoms, but not their smiling behavior, were related to the social evaluation by the interaction partner. Expressive negative symptoms, being comprised of nonverbal reductions in several nonverbal domains (facial expression, prosody, gesturing, quantity of speech), might have led to a more negative social evaluation if diminished affiliative behaviors were present on multiple nonverbal domains. This interpretation is in line with the findings of study 3. Healthy participants in general might have been able to compensate for lacking smiling behavior via other nonverbal channels. In cases with high expressive negative symptoms, more nonverbal channels were likely to be affected, which then might have led to more negative evaluations by the interaction partner. This interpretation is supported by a marginally significant bivariate relationship of expressive negative symptoms and the social evaluation by the IP (β = -.30, cf. Table 8). The effect size of this relationship approximates the significant one found in study 2 (r = -.37, cf. Table 4). In the light of these considerations, the strong association of diminished smiling behavior with more negative social evaluations found for people with schizophrenia in study 3 (β = .84, cf. Figure 11) may signify that people with schizophrenia generally were less able to compensate diminished smiling behavior via other nonverbal channels and rather exhibited a more global reduction in affiliative nonverbal behavior for which smiling behavior was a viable proxy.

The notion of a global affiliative interactional skill deficit in schizophrenia has been posited by others before (Blanchard et al., 2015; Hooley, 2010). The social cognitive basis for such a global deficit would also be a more global one. For research on schizophrenia, an empathy has been proposed as a global framework for the study of social cognitive deficits in schizophrenia (Bonfils et al., 2016; Green et al., 2015). Emotional facial mimicry is one of the behavioral components of empathy (Bonfils et al., 2016) and should therefore be related to social cognitive deficits. One of the findings of study 1 was that the mimicry of smiles on most instances occurs as quickly as within 200 ms after smile onset. This, in accordance with another study (Heerey & Crossley, 2013), suggested that smiles were anticipated throughout the interaction, so that smiling responses could be timed accurately. This anticipation process arguably involves both affect recognition and theory of mind skills. In study 3, facial affect recognition was assessed for all participants. Indeed, in healthy participants, affect recognition significantly predicted mimicry of smiles as expected. Despite recent meta-analytic evidence that showed that people with schizophrenia are impaired in facial affect recognition (Kohler et al., 2010; Savla et al., 2013), the patients in the sample of study 3 did not exhibit such an impairment. Furthermore, facial affect recognition was not related to the mimicry of smiles in people with schizophrenia. In convergence with the notion that diminished mimicry of smiles is a proxy for a global affiliative interactional skill deficit, these results suggest that in healthy participants, facial affect recognition may be a proxy for empathic ability. One explanation for the absence of a relationship of facial affect recognition and mimicry of smiles is that facial affect recognition in schizophrenia is not a viable proxy for empathic ability. That is, despite preserved facial affect recognition, theory of mind may still be impaired and could relate to lower levels of smiling mimicry. An alternative interpretation would be that the people with schizophrenia in this sample presented with rather low impairments in empathic ability. It is an open research question for future research, whether emotional facial mimicry in schizophrenia may relate to other social cognitive measures, such as theory of mind.

6.3. The role of negative symptoms

In healthy participants, negative symptoms were related to the mimicry of smiles and to the social evaluation both in studies 2 and 3. The associations in the patient sample in study 3 were considerably weaker. Negative symptoms (as assessed with the PANSS but not as assessed with the CAINS) were negatively related to the amount of smiles exhibited by the patients but not with the mimicry of smiles or the social evaluation. Thus, the findings for the healthy participants are in line with previous reports that have shown that negative symptoms relate to diminished behavioral mimicry (Kupper et al., 2015) and less positive social evaluations (Lavelle et al., 2013). Particularly the latter association would have been expected to be also present in people with schizophrenia in study 3. However, people with schizophrenia apparently were rejected by their interaction partners more or less irrespective of their negative symptom severity. It is possible that the negative symptoms indeed negatively affect social behavior, and thus the social evaluation but that in schizophrenia, this path is more indirect than in healthy people. Given the well-established association of negative symptoms with social cognitive impairments in schizophrenia (e.g. Lincoln et al., 2011), negative symptoms may particularly be reflected in the empathic deficit mentioned in the previous section. Indeed, within the patient sample in study 3, negative symptoms as assessed with the PANSS were negatively related to lower affect recognition (r = -.54; p = .004; not reported in study 3). In junction with the findings of study 2, it is also possible that different aspects of negative symptoms (i.e. motivational and expressive negative symptoms) relate to different aspects of the expressive reduction. The findings of study 2 suggested that motivational negative symptoms related to a more situation dependent behavioral reduction (i.e. selecting the appropriate response in a given situation), whereas expressive negative symptoms may relate to a more trait-like component of the behavioral reduction. Since the studies of this dissertation were not targeted at disentangling state and trait contributions to the expressive reductions per se, this might be a direction for future research.

6.4. Strengths, limitations, and design issues

The limitations to each of the single studies were discussed in the respective chapters. However, some limitations are inherent to all three studies reported here and thus need mentioning.

In all three studies, the power was at the lower end of the acceptable range. This was due to the relatively cumbersome assessment of the dyadic interactions that limited the feasibility the study to these smaller study samples. Particularly in studies 2 and 3, several of the effects were in the hypothesized direction, but small to medium in magnitude. Since the power of these studies was sufficient to detect medium to large effects with a probability of 85%, some meaningful effects might have needed to be considered insignificant. Nevertheless, most of the hypothesis tests yielded interpretable results consistent with existing theory.

The basic assumption that more smiling behavior leads to better interpersonal outcomes may be a culture specific effect. What might be perceived as aloofness in western cultures may be considered as composure in other areas of the world. This culture specificity has two interesting implications. On the one hand, if the expressive reductions in schizophrenia are a more trait-like construct and affect people in other cultures just as they do in western cultures (i.e. if patients from other cultural backgrounds exhibit the same nonverbal reductions), the interpersonal consequences differ as a function of how inappropriate the nonverbal reduction is according to the cultural norms. On the other hand, if the expressive reduction observed in western cultures is the result of an empathic deficit, as suggested by the findings of this dissertation, the behavioral correlates may be different in other cultures, but probably would result in similarly negative interpersonal consequences. To evaluate this, cross-cultural studies are needed in the field.

Another limitation inherent to the study design of employing natural conversation including unstructured phases, is, that many aspects that may have contributed to the main study outcome (willingness for future interactions) could not be controlled properly. Among these are attractiveness and competitiveness of the participants as well as coincidental matching of conversational topics or of participants' interests. As mentioned in the discussion of study 3, lower internal validity with respect to these aspects was accepted in this dissertation for the benefit of having a more ecologically valid research design. However, the studies in the dissertation varied with respect to the degree of internal validity. For example, that the mimicry of smiles was related to the willingness for future interactions in study 3 but not study 2 may be due to design differences in the two studies. In study 3, the differences in smiling mimicry were assessed between two people who interacted with the same person and then related to the willingness to interact evaluations of the same person. In doing so, in study 3, particularly two things were controlled for: the baseline level of willingness for future interactions in the evaluating person (group IP) and the baseline level of smiling mimicry that emanated from the evaluating person. These two aspects were not controlled for in study 2, thus leaving study 2 with lower internal validity than study 3. Tickle-Degnen and Rosenthal (1990) presented meta-analytic data suggesting that the effect size of the relationship of nonverbal behavior and a rapport outcome is sensitive to differences in internal validity in that lower internal validity relates to lower effect sizes. Thus, due to the less controlled study design in study 2, the influence of other sources on the willingness for future interactions might have been higher than in study 3. This is also reflected by the findings of study 2 that more global ratings of nonverbal behavior related to the willingness for future interactions and that more global assessments of social success (social network quality) were related to smiling mimicry. One way to further increase the internal validity of these kinds of studies would be to use the one-with-many design employed in study 3 with more than only two interaction partners.

Particular strengths of the studies were that facial expressions were captured objectively via EMG. Study 1 was devoted to the development of an assessment method to quantify emotional facial mimicry from the data obtained from this assessment method, since such a method was lacking in the research field. That is the objectivity of the study was higher than in most other studies that have looked at emotional facial expressions in face-to-face interactions, both in social and clinical psychology. Furthermore, several aspects ensured a high ecological validity of the assessments. Among these are investigating face-to-face interactions rather than interactions of humans with stimuli on computer screens, employing everyday study participants rather than confederates as the interaction partners, or having people talk about personal experiences rather than having them engage in a role play. The high ecological validity of the studies warranted that despite the low power for some of the analyses, generalizable results could be generated in the studies.

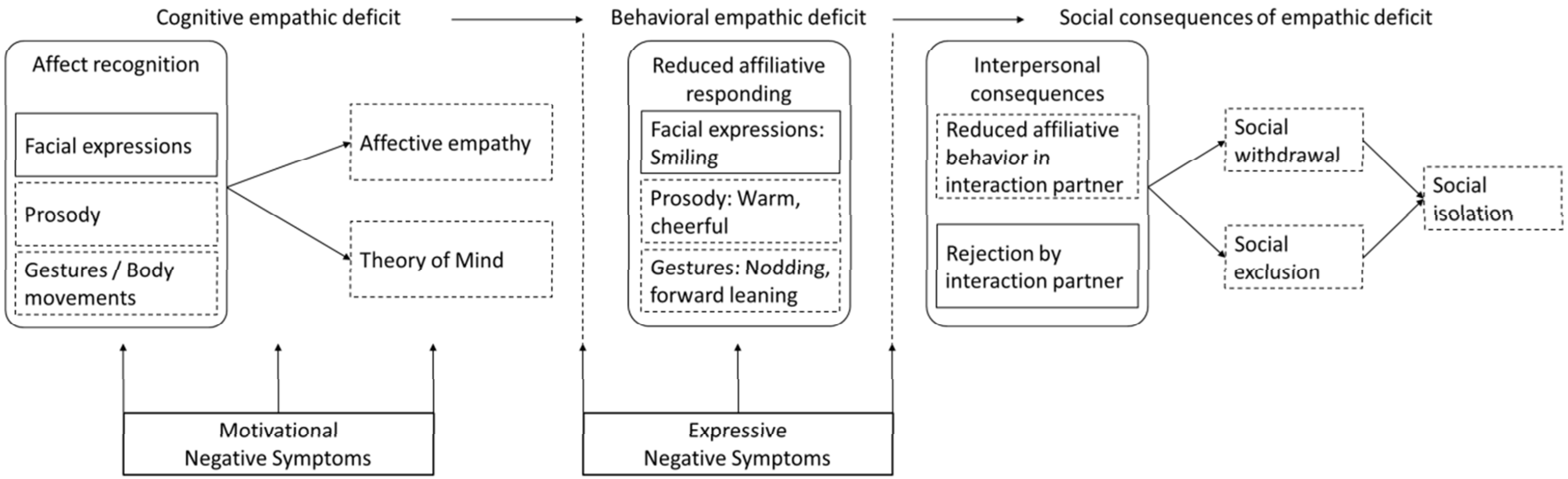


Figure 12. Proposed model for an empathic deficit in schizophrenia, both on the cognitive and behavioral level, and its corresponding social consequences. Solid lines border the parts of the model that have been investigated in studies 1-3.

6.5. Conclusions

The main aim of this dissertation was to investigate the interpersonal consequences of aberrant social behavior in schizophrenia. In order to investigate this, the three studies of this dissertation tapped aspects of both social and clinical psychology. The findings draw a rather consistent picture: People with schizophrenia are rejected by their interaction partners based on their diminished affiliative behavior. When interacting with another healthy participant, interaction partners base their negative evaluations on diminished affiliative behaviors associated with the expressive negative symptoms of schizophrenia. In this dissertation, smiling behavior as comprised of the amount of smiles expressed and the mimicry of smiles was established as a viable proxy for affiliative nonverbal reductions in schizophrenia. Additionally, the results of this dissertation suggest that emotional facial mimicry relies on empathic ability and that this ability is impaired in schizophrenia, which may account for the negative social evaluations they experience. These basic results of the three studies are summarized in Figure 12. One important implication of this dissertation project is that the study of interpersonal processes in schizophrenia is highly relevant. Particularly the study of the proposed empathic deficit in schizophrenia needs to consider interpersonal behavior as an outcome variable. Once fully understood, psychosocial interventions may target the empathic deficit and help people with schizophrenia to experience the social environment as the rewarding and supportive resource it may be.

References

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders*. American Psychiatric Association. http://doi.org/10.1176/appi.books.9780890425596

Andreasen, N. C. (1982). Negative Symptoms in Schizophrenia. Definition and Reliability. *Archives of General Psychiatry*, *39*(7), 784. http://doi.org/10.1001/archpsyc.1982.04290070020005

Back, M. D. (2015). Opening the Process Black Box: Mechanisms Underlying the Social Consequences of Personality. *European Journal of Personality*, *29*(2), 91–96. http://doi.org/10.1002/per.1999

Bailey, P. E., & Henry, J. D. (2009). Subconscious facial expression mimicry is preserved in older adulthood. *Psychology and Aging*, *24*(4), 995–1000. http://doi.org/10.1037/a0015789

Bell, M., Tsang, H. W. H., Greig, T. C., & Bryson, G. J. (2009). Neurocognition, social cognition, perceived social discomfort, and vocational outcomes in schizophrenia. *Schizophrenia Bulletin*, *35*(4), 738–47. http://doi.org/10.1093/schbul/sbm169

Bellack, A. S., Morrison, R. L., Wixted, J. T., & Mueser, K. T. (1990). An analysis of social competence in schizophrenia. *The British Journal of Psychiatry*, *156*(6), 809–818. http://doi.org/10.1192/bjp.156.6.809

Bengtsson-Tops, A., & Hansson, L. (1999). Clinical and social needs of schizophrenic outpatients living in the community: The relationship between needs and subjective quality of life. *Social Psychiatry and Psychiatric Epidemiology*, *34*(10), 513–518. http://doi.org/10.1007/s001270050169

Bengtsson-Tops, A., & Hansson, L. (2001). Quantitative and Qualitative Aspects of the Social Network in Schizophrenic Patients Living in the Community. Relationship To

Sociodemographic Characteristics and Clinical Factors and Subjective Quality of Life. *International Journal of Social Psychiatry*, *47*(3), 67–77. http://doi.org/10.1177/002076400104700307

Bernieri, F. J. (1988). Coordinated movement and rapport in teacher-student interactions. *Journal of Nonverbal Behavior*, *12*(2), 120–138. http://doi.org/10.1007/BF00986930

Blanchard, J. J., & Cohen, A. S. (2006). The structure of negative symptoms within schizophrenia: implications for assessment. *Schizophrenia Bulletin*, *32*(2), 238–45. http://doi.org/10.1093/schbul/sbj013

Blanchard, J. J., Collins, L. M., Aghevli, M. A., Leung, W. W., & Cohen, A. S. (2011). Social anhedonia and schizotypy in a community sample: the Maryland longitudinal study of schizotypy. *Schizophrenia Bulletin*, *37*(3), 587–602. http://doi.org/10.1093/schbul/sbp107

Blanchard, J. J., Horan, W. P., & Collins, L. M. (2005). Examining the latent structure of negative symptoms: Is there a distinct subtype of negative symptom schizophrenia? *Schizophrenia Research*, *77*(2), 151–165. http://doi.org/10.1016/j.schres.2005.03.022

Blanchard, J. J., Park, S. G., Catalano, L. T., & Bennett, M. E. (2015). Social affiliation and negative symptoms in schizophrenia: Examining the role of behavioral skills and subjective responding. *Schizophrenia Research*, *168*(1–2), 491–497. http://doi.org/10.1016/j.schres.2015.07.019

Blanchard, J. J., Sayers, S. L., Collins, L. M., & Bellack, A. S. (2004). Affectivity in the problem-solving interactions of schizophrenia patients and their family members. *Schizophrenia Research*, *69*(1), 105–17. http://doi.org/10.1016/j.schres.2003.07.008

Bobes, J., Arango, C., Garcia-Garcia, M., & Rejas, J. (2010). Prevalence of Negative Symptoms in Outpatients With Schizophrenia Spectrum Disorders Treated With Antipsychotics in Routine Clinical Practice. *The Journal of Clinical Psychiatry*, *71*(3), 280–286. http://doi.org/10.4088/JCP.08m04250yel

Boker, S. M., Cohn, J. F., Theobald, B.-J., Matthews, I., Brick, T. R., & Spies, J. R. (2009). Effects of damping head movement and facial expression in dyadic conversation using real-time facial expression tracking and synthesized avatars. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, *364*(1535), 3485–95. http://doi.org/10.1098/rstb.2009.0152

Boker, S. M., Rotondo, J. L., Xu, M., & King, K. (2002). Windowed cross-correlation and peak picking for the analysis of variability in the association between behavioral time series. *Psychological Methods*, *7*(3), 338–355. http://doi.org/10.1037/1082-989X.7.3.338

Bonfils, K. A., Lysaker, P. H., Minor, K. S., & Salyers, M. P. (2016). Affective empathy in schizophrenia: a meta-analysis. *Schizophrenia Research*, *175*(1–3), 109–117. http://doi.org/10.1016/j.schres.2016.03.037

Bowie, C. R., Leung, W. W., Reichenberg, A., McClure, M. M., Patterson, T. L., Heaton, R. K., & Harvey, P. D. (2008). Predicting schizophrenia patients' real-world behavior with specific neuropsychological and functional capacity measures. *Biological Psychiatry*, *63*(5), 505–11. http://doi.org/10.1016/j.biopsych.2007.05.022

Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavior Therapy and Experimental Psychiatry*, *25*(1), 49–59. http://doi.org/10.1016/0005-7916(94)90063-9

Brüne, M., Abdel-Hamid, M., Sonntag, C., Lehmkämper, C., & Langdon, R. (2009). Linking social cognition with social interaction: Non-verbal expressivity, social competence and "mentalising" in patients with schizophrenia spectrum disorders. *Behavioral and Brain Functions*, *5*, 6. http://doi.org/10.1186/1744-9081-5-6

Brüne, M., Sonntag, C., Abdel-Hamid, M., Lehmkämper, C., Juckel, G., & Troisi, A. (2008).

Nonverbal Behavior During Standardized Interviews in Patients With Schizophrenia Spectrum Disorders. *The Journal of Nervous and Mental Disease*, *196*(4), 282–288. http://doi.org/10.1097/NMD.0b013e31816a4922

Buchanan, J. (1995). Social support and schizophrenia: A review of the literature. *Archives of Psychiatric Nursing*, *9*(2), 68–76. http://doi.org/10.1016/S0883-9417(95)80003-4

Chapman, L. J., Chapman, J. P., Kwapil, T. R., Eckblad, M., & Zinser, M. C. (1994). Putatively psychosis-prone subjects 10 years later. *Journal of Abnormal Psychology*, *103*(2), 171–183. http://doi.org/10.1037/0021-843X.103.2.171

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: The perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*(6), 893–910. http://doi.org/10.1037/0022-3514.76.6.893

Chartrand, T. L., & Lakin, J. L. (2013). The Antecedents and Consequences of Human Behavioral Mimicry. *Annual Review of Psychology*, *64*(1), 285–308. http://doi.org/10.1146/annurev-psych-113011-143754

Cohen, A. S., Alpert, M., Nienow, T. M., Dinzeo, T. J., & Docherty, N. M. (2008). Computerized measurement of negative symptoms in schizophrenia. *Journal of Psychiatric Research*, *42*(10), 827–36. http://doi.org/10.1016/j.jpsychires.2007.08.008

Cohen, A. S., & Hong, S. L. (2011). Understanding constricted affect in schizotypy through computerized prosodic analysis. *Journal of Personality Disorders*, *25*(4), 478–91. http://doi.org/10.1521/pedi.2011.25.4.478

Cohen, A. S., Morrison, S. C., & Callaway, D. a. (2013). Computerized facial analysis for understanding constricted/blunted affect: initial feasibility, reliability, and validity data. *Schizophrenia Research*, *148*(1–3), 111–6. http://doi.org/10.1016/j.schres.2013.05.003

Corcoran, C. M., Kimhy, D., Parrilla-Escobar, M. a, Cressman, V. L., Stanford, A. D., Thompson, J., … Malaspina, D. (2011). The relationship of social function to depressive and negative symptoms in individuals at clinical high risk for psychosis. *Psychological Medicine*, *41*(2), 251–61. http://doi.org/10.1017/S0033291710000802

Couture, S. M., Granholm, E. L., & Fish, S. C. (2011). A path model investigation of neurocognition, theory of mind, social competence, negative symptoms and real-world functioning in schizophrenia. *Schizophrenia Research*, *125*(2–3), 152–60. http://doi.org/10.1016/j.schres.2010.09.020

Coyne, J. C. (1976). Depression and the response of others. *Journal of Abnormal Psychology*, *85*(2), 186–193. http://doi.org/10.1037/0021-843X.85.2.186

Cresswell, C. M., Kuipers, L., & Power, M. J. (1992). Social networks and support in long-term psychiatric patients. *Psychological Medicine*, *22*(4), 1019. http://doi.org/10.1017/S0033291700038587

Del-Monte, J., Capdevielle, D., Varlet, M., Marin, L., Schmidt, R. C., Salesse, R. N., … Raffard, S. (2013). Social Motor Coordination in Unaffected Relatives of Schizophrenia Patients: A Potential Intermediate Phenotype. *Frontiers in Behavioral Neuroscience*, *7*(October), 137. http://doi.org/10.3389/fnbeh.2013.00137

Dickerson, F. B., Sommerville, J., Origoni, A. E., Ringel, N. B., & Parente, F. (2002). Experiences of Stigma Among Outpatients With Schizophrenia. *Schizophrenia Bulletin*, *28*(1), 143–155. http://doi.org/10.1093/oxfordjournals.schbul.a006917

Dimberg, U. (1982). Facial Reactions to Facial Expressions. *Psychophysiology*, *19*(6), 643–647. http://doi.org/10.1111/j.1469-8986.1982.tb02516.x

Dimberg, U., Thunberg, M., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial expressions. *Psychological Science*, *11*(1), 86–89. http://doi.org/10.1111/1467-9280.00221

Dimberg, U., Thunberg, M., & Grunedal, S. (2002). Facial reactions to emotional stimuli: Automatically controlled emotional responses. *Cognition & Emotion*, *16*(4), 449–471.

http://doi.org/10.1080/02699930143000356

Ekman, P., & Friesen, W. V. (1975). *Pictures of facial affect*. Consulting Psychologists Press.

Epstein, L. H. (1990). Perception of Activity in the Zygomaticus Major and Corrugator Supercilii Muscle Regions. *Psychophysiology*, *27*(1), 68–72. http://doi.org/10.1111/j.1469-8986.1990.tb02181.x

Exner, C., & Lincoln, T. (2012). *Neuropsychologie schizophrener Störungen*. Hogrefe.

Fervaha, G., Graff-Guerrero, A., Zakzanis, K. K., Foussias, G., Agid, O., & Remington, G. (2013). Incentive motivation deficits in schizophrenia reflect effort computation impairments during cost-benefit decision-making. *Journal of Psychiatric Research*, *47*(11). http://doi.org/10.1016/j.jpsychires.2013.08.003

Fischer, A. H., & van Kleef, G. A. (2010). Where Have All the People Gone? A Plea for Including Social Interaction in Emotion Research. *Emotion Review*, *2*(3), 208–211. http://doi.org/10.1177/1754073910361980

Freeman, D., & Garety, P. (2014). Advances in understanding and treating persecutory delusions: a review. *Social Psychiatry and Psychiatric Epidemiology*, *49*(8), 1179–89. http://doi.org/10.1007/s00127-014-0928-7

Fridlund, A. J., & Cacioppo, J. T. (1986). Guidelines for Human Electromyographic Research. *Psychophysiology*, *23*(5), 567–589. http://doi.org/10.1111/j.1469-8986.1986.tb00676.x

Galderisi, S., Rossi, A., Rocca, P., Bertolino, A., Mucci, A., Bucci, P., … Emidio, G. Di. (2014). The influence of illness-related variables, personal resources and context-related factors on real-life functioning of people with schizophrenia. *World Psychiatry*, *13*, 275–287. http://doi.org/10.1002/wps.20167

Gayer-Anderson, C., & Morgan, C. (2013). Social networks, support and early psychosis: a systematic review. *Epidemiology and Psychiatric Sciences*, *22*(2), 131–46.

http://doi.org/10.1017/S2045796012000406

Gold, J. M., Strauss, G. P., Waltz, J. A., Robinson, B. M., Brown, J. K., & Frank, M. J. (2013). Negative symptoms of schizophrenia are associated with abnormal effort-cost computations. *Biological Psychiatry*, *74*(2), 130–6. http://doi.org/10.1016/j.biopsych.2012.12.022

Green, M. F., Horan, W. P., & Lee, J. (2015). Social cognition in schizophrenia. *Nature Reviews. Neuroscience*, *16*(10), 620–631. http://doi.org/10.1038/nrn4005

Grube, M. (2006). Towards an empirically based validation of intuitive diagnostic: Rümke's "praecox feeling" across the schizophrenia spectrum: preliminary results. *Psychopathology*, *39*(5), 209–17. http://doi.org/10.1159/000093921

Gur, R. E., Kohler, C. G., Ragland, J. D., Siegel, S. J., Lesko, K., Bilker, W. B., & Gur, R. C. (2006). Flat affect in schizophrenia: relation to emotion processing and neurocognitive measures. *Schizophrenia Bulletin*, *32*(2), 279–87. http://doi.org/10.1093/schbul/sbj041

Häfner, H., Nowotny, B., Löffler, W., an der Heiden, W., & Maurer, K. (1995). When and how does schizophrenia produce social deficits? *European Archives of Psychiatry and Clinical Neuroscience*, *246*(1), 17–28. http://doi.org/10.1007/BF02191811

Hamilton, N. G., Ponzoha, C. a, Cutler, D. L., & Weigel, R. M. (1989). Social networks and negative versus positive symptoms of schizophrenia. *Schizophrenia Bulletin*, *15*(4), 625–633.

Harley, E. W.-Y., Boardman, J., & Craig, T. (2012). Friendship in people with schizophrenia: a survey. *Social Psychiatry and Psychiatric Epidemiology*, *47*(8), 1291–1299. http://doi.org/10.1007/s00127-011-0437-x

Hatfield, E., Cacioppo, J. T., & Rapson, R. L. (1994). *Emotional contagion.* Editions de la Maison des Sciences de l'Homme.

Heerey, E. A. (2015). Decoding the Dyad: Challenges in the Study of Individual Differences in Social Behavior. *Current Directions in Psychological Science*, *24*(4), 285–291. http://doi.org/10.1177/0963721415570731

Heerey, E. A., & Crossley, H. M. (2013). Predictive and reactive mechanisms in smile reciprocity. *Psychological Science*, *24*(8), 1446–55. http://doi.org/10.1177/0956797612472203

Hess, U., & Blairy, S. (2001). Facial mimicry and emotional contagion to dynamic emotional facial expressions and their influence on decoding accuracy. *International Journal of Psychophysiology*, *40*(2), 129–141. http://doi.org/10.1016/S0167-8760(00)00161-6

Hess, U., Blairy, S., & Kleck, R. E. (2000). The Influence of Facial Emotion Displays, Gender, and Ethnicity on Judgments of Dominance and Affiliation. *Journal of Nonverbal Behavior*, *24*(4), 265–283. http://doi.org/10.1023/A:1006623213355

Hess, U., & Bourgeois, P. (2010). You smile--I smile: emotion expression in social interaction. *Biological Psychology*, *84*(3), 514–20. http://doi.org/10.1016/j.biopsycho.2009.11.001

Hess, U., & Fischer, A. H. (2013). Emotional Mimicry as Social Regulation. *Personality and Social Psychology Review*, *17*(2), 142–157. http://doi.org/10.1177/1088868312472607

Hooley, J. M. (2010). Social Factors in Schizophrenia. *Current Directions in Psychological Science*, *19*(4), 238–242. http://doi.org/10.1177/0963721410377597

Horan, W. P., Brown, S. A., & Blanchard, J. J. (2007). Social anhedonia and schizotypy: the contribution of individual differences in affective traits, stress, and coping. *Psychiatry Research*, *149*(1–3), 147–56. http://doi.org/10.1016/j.psychres.2006.06.002

Horan, W. P., Kring, A. M., Gur, R. E., Reise, S. P., & Blanchard, J. J. (2011). Development and psychometric validation of the Clinical Assessment Interview for Negative Symptoms (CAINS). *Schizophrenia Research*, *132*(2–3), 140–5. http://doi.org/10.1016/j.schres.2011.06.030

Horan, W. P., Pineda, J. a, Wynn, J. K., Iacoboni, M., & Green, M. F. (2014). Some markers of mirroring appear intact in schizophrenia: evidence from mu suppression. *Cognitive, Affective & Behavioral Neuroscience*. http://doi.org/10.3758/s13415-013-0245-8

Horan, W. P., Subotnik, K. L., Snyder, K. S., & Nuechterlein, K. H. (2006). Do Recent-Onset Schizophrenia Patients Experience a “Social Network Crisis”? *Psychiatry: Interpersonal and Biological Processes*, *69*(2), 115–129. http://doi.org/10.1521/psyc.2006.69.2.115

Hühnel, I., Fölster, M., Werheid, K., & Hess, U. (2014). Empathic reactions of younger and older adults: No age related decline in affective responding. *Journal of Experimental Social Psychology*, *50*(1), 136–143. http://doi.org/10.1016/j.jesp.2013.09.011

Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., Rizzolatti, G., … Jeannerod, M. (1999). Cortical mechanisms of human imitation. *Science (New York, N.Y.)*, *286*(5449), 2526–8. http://doi.org/10.1126/science.286.5449.2526

Jones, P. B., Bebbington, P., Foerster, A., Lewis, S. W., Murray, R. M., Russell, A., … Wilkins, S. (1993). Premorbid social underachievement in schizophrenia. Results from the Camberwell Collaborative Psychosis Study. *The British Journal of Psychiatry : The Journal of Mental Science*, *162*(1), 65–71. http://doi.org/10.1192/bjp.162.1.65

Kashy, D. A., & Kenny, D. A. (1999). The analysis of data from dyads and groups. In H. T. Reis & C. M. Judd (Eds.), *Handbook of Research Methods in Social Psychology*. New York: Cambridge University Press.

Kavanagh, D. J. (1992). Recent developments in expressed emotion and schizophrenia. *The British Journal of Psychiatry : The Journal of Mental Science*, *160*(5), 601–20. http://doi.org/10.1192/bjp.160.5.601

Kay, S. R., Fiszbein, A., & Opler, L. A. (1987). The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophrenia Bulletin*, *13*(2), 261–76. http://doi.org/10.1093/schbul/13.2.261

Kendler, K. S., Thacker, L., & Walsh, D. (1996). Self-report Measures of Schizotypy as Indices of Familial Vulnerability to Schizophrenia. *Schizophrenia Bulletin*, *22*(3), 511–520. http://doi.org/10.1093/schbul/22.3.511

Kenny, D. A. (2011). APIM (Indistinguishable Dyads) Macro. Retrieved March 30, 2016, from http://davidakenny.net/dtt/apimindist.htm

Kenny, D. A. (2015). Dyadic Analysis. Retrieved July 4, 2016, from http://davidakenny.net/dyad.htm#Top5

Kenny, D. A., Kashy, D. A., & Cook, W. L. (2006). *Dyadic data analysis. Methodology in the social sciences.* New York: Guilford Press.

Kirkpatrick, B., Fenton, W. S., Carpenter, W. T., & Marder, S. R. (2006). The NIMH-MATRICS consensus statement on negative symptoms. *Schizophrenia Bulletin*, *32*(2), 214–9. http://doi.org/10.1093/schbul/sbj053

Kirkpatrick, B., Strauss, G. P., Nguyen, L., Fischer, B. A., Daniel, D. G., Cienfuegos, A., & Marder, S. R. (2011). The brief negative symptom scale: psychometric properties. *Schizophrenia Bulletin*, *37*(2), 300–5. http://doi.org/10.1093/schbul/sbq059

Kohler, C. G., Walker, J. B., Martin, E. A., Healey, K. M., & Moberg, P. J. (2010). Facial Emotion Perception in Schizophrenia: A Meta-analytic Review. *Schizophrenia Bulletin*, *36*(5), 1009–1019. http://doi.org/10.1093/schbul/sbn192

Krause, R., Steimer, E., Sänger-Alt, C., & Wagner, G. (1989). Facial expression of schizophrenic patients and their interaction partners. *Interpersonal and Biological Processes*, *52*(1), 1–12.

Kring, A. M., & Barch, D. M. (2014). The motivation and pleasure dimension of negative symptoms: neural substrates and behavioral outputs. *European Neuropsychopharmacology*, *24*(5), 725–36. http://doi.org/10.1016/j.euroneuro.2013.06.007

Kring, A. M., & Earnst, K. S. (1999). Stability of emotional responding in schizophrenia. *Behavior Therapy*, *30*(3), 373–388. http://doi.org/10.1016/S0005-7894(99)80016-1

Kring, A. M., & Elis, O. (2013). Emotion Deficits in People with Schizophrenia. *Annual Review of Clinical Psychology*, *9*, 409–33. http://doi.org/10.1146/annurev-clinpsy-050212-185538

Kring, A. M., Gur, R. E., Blanchard, J. J., Horan, W. P., & Reise, S. P. (2013). The Clinical Assessment Interview for Negative Symptoms (CAINS): final development and validation. *The American Journal of Psychiatry*, *170*(2), 165–72. http://doi.org/10.1176/appi.ajp.2012.12010109

Kring, A. M., Kerr, S. L., & Earnst, K. S. (1999). Schizophrenic patients show facial reactions to emotional facial expressions. *Psychophysiology*, *36*(2), 186–192. http://doi.org/10.1111/1469-8986.3620186

Kring, A. M., & Moran, E. K. (2008). Emotional response deficits in schizophrenia: insights from affective science. *Schizophrenia Bulletin*, *34*(5), 819–34. http://doi.org/10.1093/schbul/sbn071

Kupper, Z., Ramseyer, F., Hoffmann, H., Kalbermatten, S., & Tschacher, W. (2010). Video-based quantification of body movement during social interaction indicates the severity of negative symptoms in patients with schizophrenia. *Schizophrenia Research*, *121*(1–3), 90–100. http://doi.org/10.1016/j.schres.2010.03.032

Kupper, Z., Ramseyer, F., Hoffmann, H., & Tschacher, W. (2015). Nonverbal Synchrony in Social Interactions of Patients with Schizophrenia Indicates Socio-Communicative Deficits. *Plos One*, *10*(12), e0145882. http://doi.org/10.1371/journal.pone.0145882

Lakin, J. L., & Chartrand, T. L. (2003). Using Nonconscious Behavioral Mimicry to Create Affiliation and Rapport. *Psychological Science*, *14*(4), 334–339. http://doi.org/10.1111/1467-9280.14481

Langner, O., Dotsch, R., Bijlstra, G., Wigboldus, D. H. J., Hawk, S. T., & van Knippenberg, A. (2010). Presentation and validation of the Radboud Faces Database. *Cognition & Emotion*, *24*(8), 1377–1388. http://doi.org/10.1080/02699930903485076

Lanzetta, J. T., & Englis, B. G. (1989). Expectations of cooperation and competition and their effects on observers' vicarious emotional responses. *Journal of Personality and Social Psychology*, *56*(4), 543–554. http://doi.org/10.1037/0022-3514.56.4.543

Laroche, J., Berardi, A. M., & Brangier, E. (2014). Embodiment of intersubjective time: relational dynamics as attractors in the temporal coordination of interpersonal behaviors and experiences. *Frontiers in Psychology*, *5*(October), 1–17. http://doi.org/10.3389/fpsyg.2014.01180

Larsen, J. T., Norris, C. J., & Cacioppo, J. T. (2003). Effects of positive and negative affect on electromyographic activity over zygomaticus major and corrugator supercilii. *Psychophysiology*, *40*(5), 776–785. http://doi.org/10.1111/1469-8986.00078

Lavelle, M. (2011). *Nonverbal communication in schizophrenia: A 3-D Analysis of patients' social interactions.* Queen Mary, University of London.

Lavelle, M., Dimic, S., Wildgrube, C., McCabe, R., & Priebe, S. (2015). Non-verbal communication in meetings of psychiatrists and patients with schizophrenia. *Acta Psychiatrica Scandinavica*, *131*, 197–205. http://doi.org/10.1111/acps.12319

Lavelle, M., Healey, P. G. T., & McCabe, R. (2013). Is Nonverbal Communication Disrupted in Interactions Involving Patients With Schizophrenia? *Schizophrenia Bulletin*, *39*(5), 1150–1158. http://doi.org/10.1093/schbul/sbs091

Lavelle, M., Healey, P. G. T., & McCabe, R. (2014). Nonverbal behavior during face-to-face social interaction in schizophrenia: a review. *The Journal of Nervous and Mental Disease*, *202*(1), 47–54. http://doi.org/10.1097/NMD.0000000000000031

Lehrl, S. (1999). *Mehrfachwahl-Wortschatz-Intelligenztest: MWT-B*. book, Balingen: Spitta.

Leppin, A., Quast, H. H., & Sarason, I. G. (1986). Fragebogen zur sozialen Unterstützung (Kurzform) SSQ6-G. In R. Schwarzer (Ed.), *Skalen zur Befindlichkeit und Persönlichkeit* (pp. 195–202). Forschungsbericht 5. Institut für Psychologie, Pädagogische Psychologie der Freien Universität Berlin.

Leung, W. W., Couture, S. M., Blanchard, J. J., Lin, S., & Llerena, K. (2010). Is social anhedonia related to emotional responsivity and expressivity? A laboratory study in women. *Schizophrenia Research*, *124*(1–3), 66–73. http://doi.org/10.1016/j.schres.2010.06.012

Likowski, K. U., Mühlberger, A., Seibt, B., Pauli, P., & Weyers, P. (2008). Modulation of facial mimicry by attitudes. *Journal of Experimental Social Psychology*, *44*(4), 1065–1072. http://doi.org/10.1016/j.jesp.2007.10.007

Lincoln, T. M., Mehl, S., Kesting, M.-L., & Rief, W. (2011). Negative symptoms and social cognition: identifying targets for psychological interventions. *Schizophrenia Bulletin*, *37 Suppl 2*(suppl 2), S23–S32. http://doi.org/10.1093/schbul/sbr066

Lipton, F. R., Cohen, C. I., Fischer, E., & Katz, S. E. (1981). Schizophrenia: A Network Crisis. *Schizophrenia Bulletin*, *7*(1), 144–151. http://doi.org/10.1093/schbul/7.1.144

Llerena, K., Park, S. G., Couture, S. M., & Blanchard, J. J. (2012). Social anhedonia and affiliation: examining behavior and subjective reactions within a social interaction. *Psychiatry Research*, *200*(2–3), 679–86. http://doi.org/10.1016/j.psychres.2012.07.050

Macdonald, E. (2000). The quantity and quality of the social networks of young people with early psychosis compared with closely matched controls. *Schizophrenia Research*, *46*(1), 25–30. http://doi.org/10.1016/S0920-9964(00)00024-4

Macdonald, E. M., Jackson, H. J., Hayes, R. L., Baglioni, A. J., & Madden, C. (1998). Social skill as a determinant of social networks and perceived social support in schizophrenia. *Schizophrenia Research*, *29*(3), 275–286. http://doi.org/10.1016/S0920-9964(97)00096-

0

Mattes, R. M., Schneider, F., Heimann, H., & Birbaumer, N. (1995). Reduced emotional response of schizophrenic patients in remission during social interaction. *Schizophrenia Research*, *17*(3), 249–255. http://doi.org/10.1016/0920-9964(95)00014-3

Mauersberger, H., Blaison, C., Kafetsios, K., Kessler, C. L., & Hess, U. (2015). Individual Differences in Emotional Mimicry: Underlying Traits and Social Consequences. *European Journal of Personality*, *29*(5), 512–529. http://doi.org/10.1002/per.2008

McGlade, N., Behan, C., Hayden, J., O'Donoghue, T., Peel, R., Haq, F., … Donohoe, G. (2008). Mental state decoding v. mental state reasoning as a mediator between cognitive and social function in psychosis. *The British Journal of Psychiatry : The Journal of Mental Science*, *193*(1), 77–8. http://doi.org/10.1192/bjp.bp.107.044198

McGrath, J., Saha, S., Chant, D., & Welham, J. (2008). Schizophrenia: a concise overview of incidence, prevalence, and mortality. *Epidemiologic Reviews*, *30*(1), 67–76. http://doi.org/10.1093/epirev/mxn001

McIntosh, D. N., Reichmann-Decker, A., Winkielman, P., & Wilbarger, J. L. (2006). When the social mirror breaks: deficits in automatic, but not voluntary, mimicry of emotional facial expressions in autism. *Developmental Science*, *9*(3), 295–302. http://doi.org/10.1111/j.1467-7687.2006.00492.x

Messinger, D. S., Mahoor, M. H., Chow, S.-M., & Cohn, J. F. (2009). Automated Measurement of Facial Expression in Infant-Mother Interaction: A Pilot Study. *Infancy*, *14*(3), 285–305. http://doi.org/10.1080/15250000902839963

Miles, L. K., Nind, L. K., & Macrae, C. N. (2009). The rhythm of rapport: Interpersonal synchrony and social perception. *Journal of Experimental Social Psychology*, *45*(3), 585–589. http://doi.org/10.1016/j.jesp.2009.02.002

Mueser, K. T., Bellack, A. S., & Brady, E. U. (1990). Hallucinations in schizophrenia. *Acta*

Psychiatrica Scandinavica, *82*(1), 26–29. http://doi.org/10.1111/j.1600-0447.1990.tb01350.x

Nestler, S., Grimm, K. J., & Schönbrodt, F. D. (2015). The Social consequences and mechanisms of personality: How to analyse longitudinal data from individual, dyadic, round-robin and network designs. *European Journal of Personality*, *29*(2), 272–295. http://doi.org/10.1002/per.1997

Norman, R. M. G., Malla, A. K., Manchanda, R., Harricharan, R., Takhar, J., & Northcott, S. (2005). Social support and three-year symptom and admission outcomes for first episode psychosis. *Schizophrenia Research*, *80*(2–3), 227–34. http://doi.org/10.1016/j.schres.2005.05.006

Norman, R. M. G., Windell, D., Manchanda, R., Harricharan, R., & Northcott, S. (2012). Social support and functional outcomes in an early intervention program. *Schizophrenia Research*, *140*(1–3), 37–40. http://doi.org/10.1016/j.schres.2012.07.003

Penn, D. L., Kohlmaier, J. R., & Corrigan, P. W. (2000). Interpersonal factors contributing to the stigma of schizophrenia: social skills, perceived attractiveness, and symptoms. *Schizophrenia Research*, *45*(1–2), 37–45. http://doi.org/10.1016/S0920-9964(99)00213-3

Piskulic, D., Addington, J., Cadenhead, K. S., Cannon, T. D., Cornblatt, B. a, Heinssen, R., … McGlashan, T. H. (2012). Negative symptoms in individuals at clinical high risk of psychosis. *Psychiatry Research*, *196*(2–3), 220–4. http://doi.org/10.1016/j.psychres.2012.02.018

Raffard, S., Salesse, R. N., Marin, L., Del-Monte, J., Schmidt, R. C., Varlet, M., … Capdevielle, D. (2015). Social priming enhances interpersonal synchronization and feeling of connectedness towards schizophrenia patients. *Scientific Reports*, *5*, 8156. http://doi.org/10.1038/srep08156

Ramseyer, F., & Tschacher, W. (2011). Nonverbal synchrony in psychotherapy: coordinated body movement reflects relationship quality and outcome. *Journal of Consulting and Clinical Psychology*, *79*(3), 284–95. http://doi.org/10.1037/a0023419

Reitan, R. M. (1992). *Trail Making Test: Manual for administration and scoring*. book, Reitan Neuropsychology Laboratory.

Riehle, M., Jung, E., Wiesjahn, M., Mehl, S., Rief, W., & Lincoln, T. M. (2015). What's in an item? Predicting social outcomes in schizophrenia spectrum disorders from the PANSS item "Poor Rapport". *Schizophrenia Research*, *168*(1–2), 593–4. http://doi.org/10.1016/j.schres.2015.08.026

Rümke, H. (1942). Das Kernsymptom der Schizophrenie und das "Praecox Gefühl." *Zentralblatt Gesamte Neurologie Und Psychiatrie*, *102*, 168–169.

Savla, G. N., Vella, L., Armstrong, C. C., Penn, D. L., & Twamley, E. W. (2013). Deficits in Domains of Social Cognition in Schizophrenia: A Meta-Analysis of the Empirical Evidence. *Schizophrenia Bulletin*, *39*(5), 979–992. http://doi.org/10.1093/schbul/sbs080

Schiffman, J., Walker, E. F., Ekstrom, M., Schulsinger, F., Sorensen, H., & Mednick, S. (2004). Childhood Videotaped Social and Neuromotor Precursors of Schizophrenia: A Prospective Investigation. *American Journal of Psychiatry*, *161*(11), 2021–2027. http://doi.org/10.1176/appi.ajp.161.11.2021

Stangier, U., Heidenreich, T., Berardi, A., Golbs, U., & Hoyer, J. (1999). Die Erfassung sozialer Phobie durch die Social Interaction Anxiety Scale (SIAS) und die Social Phobia Scale (SPS). *Zeitschrift Für Klinische Psychologie Und Psychotherapie*, *28*(1), 28–36. http://doi.org/10.1026//0084-5345.28.1.28

Stel, M., van Baaren, R. B., Blascovich, J., van Dijk, E., McCall, C., Pollmann, M. M. H., … Vonk, R. (2010). Effects of a priori liking on the elicitation of mimicry. *Experimental Psychology*, *57*(6), 412–8. http://doi.org/10.1027/1618-3169/a000050

Stel, M., & Vonk, R. (2010). Mimicry in social interaction: benefits for mimickers, mimickees, and their interaction. *British Journal of Psychology*, *101*(Pt 2), 311–23. http://doi.org/10.1348/000712609X465424

Strauss, G. P., Allen, D. N., Miski, P., Buchanan, R. W., Kirkpatrick, B., & Carpenter, W. T. (2012). Differential patterns of premorbid social and academic deterioration in deficit and nondeficit schizophrenia. *Schizophrenia Research*, *135*(1–3), 134–8. http://doi.org/10.1016/j.schres.2011.11.007

Strauss, G. P., Frank, M. J., Waltz, J. A., Kasanova, Z., Herbener, E. S., & Gold, J. M. (2011). Deficits in Positive Reinforcement Learning and Uncertainty-Driven Exploration Are Associated with Distinct Aspects of Negative Symptoms in Schizophrenia. *Biological Psychiatry*, *69*(5), 424–431. http://doi.org/10.1016/j.biopsych.2010.10.015

Strauss, G. P., Hong, L. E., Gold, J. M., Buchanan, R. W., McMahon, R. P., Keller, W. R., … Kirkpatrick, B. (2012a). Factor structure of the Brief Negative Symptom Scale. *Schizophrenia Research*, *142*(1–3), 96–8. http://doi.org/10.1016/j.schres.2012.09.007

Strauss, G. P., Hong, L. E., Gold, J. M., Buchanan, R. W., McMahon, R. P., Keller, W. R., … Kirkpatrick, B. (2012b). Factor structure of the Brief Negative Symptom Scale. *Schizophrenia Research*, *142*(1–3), 96–8. http://doi.org/10.1016/j.schres.2012.09.007

Streit, M., Ioannides, A., Sinnemann, T., Wölwer, W., Dammers, J., Zilles, K., & Gaebel, W. (2001). Disturbed Facial Affect Recognition in Patients With Schizophrenia Associated With Hypoactivity in Distributed Brain Regions: A Magnetoencephalographic Study. *American Journal of Psychiatry*, *158*(9), 1429–1436. http://doi.org/10.1176/appi.ajp.158.9.1429

Tassinary, L. G., Cacioppo, J. T., & Vanman, E. J. (2007). The Skeletomotor System: Surface Electromyography. In J. T. Cacioppo, L. G. Tassinary, & G. Bernston (Eds.), *Handbook of Psychophysiology* (3rd ed., pp. 267–299). Cambridge: Cambridge University Press.

Thorup, A., Petersen, L., Jeppesen, P., Øhlenschlaeger, J., Christensen, T., Krarup, G., … Nordentoft, M. (2006). Social network among young adults with first-episode schizophrenia spectrum disorders: results from the Danish OPUS trial. *Social Psychiatry and Psychiatric Epidemiology*, *41*(10), 761–770. http://doi.org/10.1007/s00127-006-0098-3

Tickle-Degnen, L., & Rosenthal, R. (1990). The Nature of Rapport and Its Nonverbal Correlates. *Psychological Inquiry*, *1*(4), 285–293. http://doi.org/10.1207/s15327965pli0104_1

Trémeau, F., Malaspina, D., Duval, F., Corrêa, H., Hager-Budny, M., Coin-Bariou, L., … Gorman, J. M. (2005). Facial expressiveness in patients with schizophrenia compared to depressed patients and nonpatient comparison subjects. *The American Journal of Psychiatry*, *162*(1), 92–101. http://doi.org/10.1176/appi.ajp.162.1.92

Troisi, A., Pasini, A., Bersani, G., Mauro, M. Di, & Ciani, N. (1991). Negative symptoms and visual behavior in DSM-III-R prognostic subtypes of schizophreniform disorder. *Acta Psychiatrica Scandinavica*, *83*(5), 391–394. http://doi.org/10.1111/j.1600-0447.1991.tb05562.x

Troisi, A., Spalletta, G., & Pasini, A. (1998). Non-verbal behaviour deficits in schizophrenia: an ethological study of drug-free patients. *Acta Psychiatrica Scandinavica*, *97*(2), 109–115. http://doi.org/10.1111/j.1600-0447.1998.tb09971.x

Tschacher, W., Rees, G. M., & Ramseyer, F. (2014). Nonverbal synchrony and affect in dyadic interactions. *Frontiers in Psychology*, *5*, 1323. http://doi.org/10.3389/fpsyg.2014.01323

van der Schalk, J., Fischer, A. H., Doosje, B., Wigboldus, D., Hawk, S. T., Rotteveel, M., & Hess, U. (2011). Convergent and divergent responses to emotional displays of ingroup and outgroup. *Emotion*, *11*(2), 286–98. http://doi.org/10.1037/a0022582 van Os, J., & Kapur, S. (2009). Schizophrenia. *The Lancet*, *374*(9690), 635–645. http://doi.org/10.1016/S0140-6736(09)60995-8

Varcin, K. J., Bailey, P. E., & Henry, J. D. (2010). Empathic deficits in schizophrenia: the potential role of rapid facial mimicry. *Journal of the International Neuropsychological Society*, *16*(4), 621–9. http://doi.org/10.1017/S1355617710000329

Varlet, M., Marin, L., Raffard, S., Schmidt, R. C., Capdevielle, D., Boulenger, J.-P., … Bardy, B. G. (2012). Impairments of social motor coordination in schizophrenia. *PloS One*, *7*(1), e29772. http://doi.org/10.1371/journal.pone.0029772

Walker, E. F., Grimes, K. E., Davis, D. M., & Smith, A. J. (1993). Childhood precursors of schizophrenia: facial expressions of emotion. *American Journal of Psychiatry*, *150*(11), 1654–1660. http://doi.org/10.1176/ajp.150.11.1654

Walther, S., & Mittal, V. A. (2016). Why We Should Take a Closer Look at Gestures. *Schizophrenia Bulletin*, (JANUARY), sbv229. http://doi.org/10.1093/schbul/sbv229

Walther, S., Stegmayer, K., Horn, H., Rampa, L., Razavi, N., Müller, T. J., & Strik, W. (2015). The Longitudinal Course of Gross Motor Activity in Schizophrenia - Within and between Episodes. *Frontiers in Psychiatry*, *6*, 10. http://doi.org/10.3389/fpsyt.2015.00010

Wechsler, D. (1981). *Wechsler adult intelligence scale-revised*. book, Psychological Corporation.

Wexler, B. E., Levenson, L., Warrenburg, S., & Price, L. H. (1994). Decreased perceptual sensitivity to emotion-evoking stimuli in depression. *Psychiatry Research*, *51*(2), 127–138. http://doi.org/10.1016/0165-1781(94)90032-9

Wittchen, H.-U., Fydrich, T., & Zaudig, M. (1997). *SKID: Strukturiertes Klinisches Interview für DSM-IV; Achse I und II. Achse I: psychische Störungen. SKID-I*. Göttingen: Hogrefe.

Wölwer, W., & Frommann, N. (2011). Social-cognitive remediation in schizophrenia:

generalization of effects of the Training of Affect Recognition (TAR). *Schizophrenia Bulletin*, *37 Suppl 2*, S63-70. http://doi.org/10.1093/schbul/sbr071

Wölwer, W., Frommann, N., Halfmann, S., Piaszek, A., Streit, M., & Gaebel, W. (2005). Remediation of impairments in facial affect recognition in schizophrenia: efficacy and specificity of a new training program. *Schizophrenia Research*, *80*(2–3), 295–303. http://doi.org/10.1016/j.schres.2005.07.018

Woods, S. W. (2003). Chlorpromazine Equivalent Doses for the Newer Atypical Antipsychotics. *The Journal of Clinical Psychiatry*, *64*(6), 663–667. http://doi.org/10.4088/JCP.v64n0607

Woods, S. W. (2005). Calculation of CPZ Equivalents. Retrieved July 19, 2016, from www.scottwilliamwoods.com/files/Equivtext.doc

Zhang, Z. (2012). Microsoft kinect sensor and its effect. *IEEE Multimedia*, *19*(2), 4–10. http://doi.org/10.1109/MMUL.2012.24

Appendix A

Instructions and measures

Participant information sheets (for controls): Diagnostic assessment

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Projektleiter u. Ansprechpartner für eventuelle Rückfragen:
Marcel Riehle
Telefon: *040-42838-9373*

Allgemeine Teilnehmerinformation über die Untersuchung

Titel der Studie: Unterschiede in der sozialen Interaktion bei unbekannten und befreundeten Gesprächspartnern – Teil 1

Herzlich willkommen zum ersten Teil unserer Studie zu „Unterschieden in der sozialen Interaktion bei unbekannten und befreundeten Gesprächspartnern"! Wir danken Ihnen für Ihr Interesse an dieser Studie. Diese Probandeninformation soll Sie über den allgemeinen Ablauf unserer Studie und über unsere Vorkehrungen zum Datenschutz aufklären.

Wir möchten mit dieser Studie untersuchen, ob sich bei Menschen die Gespräche mit unbekannten Personen von den Gesprächen mit guten Freunden unterscheiden. Hierzu laden wir sich fremde Probanden und befreundete Probanden zur Teilnahme an der Studie ein. Sie sind Teil der Gruppe von Probanden, die mit einer unbekannten Person sprechen werden. Das bedeutet, dass Sie an einem weiteren Termin mit einer Ihnen unbekannten Person ein Gespräch führen sollen.

Ablauf der heutigen Untersuchung

Die heutige Untersuchung besteht aus insgesamt zwei Teilen: zunächst erfragen wir in einem Interview einzelne Angaben zu Ihrer Person (z.B. Ihr Alter) und stellen Fragen zu einigen Bereichen Ihres emotionalen Erlebens und eventuellen psychischen Belastungen. Im Rahmen dieses Interviews werden wir außerdem auch noch einige Fragen zu Ihrer Freizeitgestaltung und zur Häufigkeit einiger Ihrer zwischenmenschlichen Kontakte stellen. Anschließend sollen Sie drei kurze Tests zur Aufmerksamkeit und zum Wortschatz absolvieren. Am heutigen Tag dauert die Untersuchung in etwa 1 ½ Stunden. Sie können hierbei jederzeit nach einer Pause verlangen.

Freiwilligkeit und Anonymität

Die Teilnahme an der Studie ist freiwillig. Sie können die Teilnahme an dieser Studie jederzeit und ohne Angabe von Gründen abbrechen und Ihr Einverständnis zur Teilnahme widerrufen, ohne dass Ihnen daraus Nachteile entstehen. Auch wenn Sie die Studie vorzeitig abbrechen, haben Sie Anspruch auf eine anteilige Vergütung für den bis dahin erbrachten Zeitaufwand.

Die im Rahmen dieser Studie erhobenen Daten und persönlichen Mitteilungen werden vertraulich behandelt. So unterliegen diejenigen Mitarbeiter, die durch direkten Kontakt mit Ihnen über personenbezogene Daten verfügen, der Schweigepflicht. Des Weiteren wird eine Veröffentlichung der Ergebnisse der Studie nur in anonymisierter Form erfolgen. Das heißt, dass Ihre Daten nicht Ihrer Person zugeordnet werden können.

Datenschutz

Die Aufzeichnung und Auswertung der Daten erfolgt pseudonymisiert, das heißt unter Verwendung eines persönlichen Codes und *ohne* Angabe Ihres Klarnamens. Es existiert eine Liste auf Papier, die Ihren Namen mit diesem Code verbindet. Diese Liste ist nur dem Projektleiter (Marcel Riehle) zugänglich und wird nach Abschluss der Datenerhebung bzw. der Datenauswertung vernichtet. Ihr individueller Code ergibt sich aus einzelnen persönlichen Angaben, wie z.B. dem ersten Buchstaben des Vornamens Ihrer Mutter, kann durch Sie so jederzeit erneut generiert werden und ergibt nur für Sie einen Sinn. Sie können Ihr Einverständnis zur Aufbewahrung Ihrer Daten widerrufen, ohne dass Ihnen daraus Nachteile entstehen. Sie können so jederzeit eine Löschung all Ihrer Daten verlangen. Wenn die Codierliste bereits vernichtet worden ist, kann Ihr Datensatz von unserer Seite aus nicht mehr identifiziert werden. Dann sind Sie die einzige Person, die Ihren Code kennt über den Ihre Daten identifizierbar sind. Anstelle einer kompletten Löschung der Daten können Sie jederzeit eine *Anonymisierung* Ihrer Daten verlangen. In diesem Fall würden wir Ihren persönlichen Code durch einen artifiziellen Code ersetzen, der nicht Ihrer Person zugeordnet werden kann. Anschließend sind Ihre Daten anonymisiert. Eine Löschung Ihrer Daten ist dann allerdings nicht mehr möglich. Die Daten werden zu Forschungszwecken weiter verwendet und bleiben 10 Jahre gespeichert.

Vergütung

Für die Teilnahme an beiden Terminen der Untersuchung erhalten Sie 10€ pro Stunde (entsprechend der aufgebrachten Zeit), bei vollständiger Teilnahme sind dies 40€. Bei Vorzeitigem Abbruch der Studie, erhalten Sie eine Anteilige Entschädigung. Die Vergütung wird Ihnen in bar ausgezahlt. Bei Empfang des Geldes müssen Sie eine Quittung mit Angabe Ihres Namens und Ihrer Adresse unterschreiben. Alle diesbezüglichen Informationen werden völlig separat von den Untersuchungsdaten aufbewahrt.

Sie erhalten außerdem eine Kopie dieser Probandeninformation sowie vom Versuchsleiter unterzeichnete Kopien der beiden Einverständniserklärungen für Ihre Unterlagen.

Sollten Sie nun noch Fragen zur heutigen Untersuchung haben, bitten wir Sie, diese nun zu stellen.

Noch einmal vielen Dank für Ihre Teilnahme!

Mit den besten Grüßen,

M. Riehle

Marcel Riehle
Projektleitung

Participant information sheets (for controls): Interaction assessment:

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Projektleiter u. Ansprechpartner für eventuelle Rückfragen:

Marcel Riehle

Telefon: *040-42838-9373*

Allgemeine Teilnehmerinformation über die Untersuchung

Titel der Studie: Unterschiede in der sozialen Interaktion bei unbekannten und befreundeten Gesprächspartnern

Herzlich willkommen zurück zu einem weiteren Teil unserer Studie! Wir danken Ihnen für Ihr erneutes Erscheinen zu dieser Studie.

Wie Sie sich vielleicht erinnern, möchten wir mit dieser Studie untersuchen, ob sich bei Menschen die Gespräche mit unbekannten Personen von den Gesprächen mit guten Freunden unterscheiden. Hierzu laden wir sich fremde Probanden und befreundete Probanden zur Teilnahme an der Studie ein. Sie sind Teil der Gruppe von Probanden, die mit einer unbekannten Person sprechen werden. Außerdem interessiert uns, wie Menschen, die eher weniger an Gesprächen mit anderen Menschen interessiert sind, ein solches Gespräch führen.

Ablauf der Studie

Die folgende Untersuchung besteht aus insgesamt vier Teilen, zwischen denen immer kurze Pausen eingelegt werden. Insgesamt dauert das Experiment am heutigen Tag in etwa 70 Minuten.

Sie werden zunächst gebeten, vier Fragebögen auszufüllen.

Danach setzen Sie sich zusammen mit einer zweiten Person in einen anderen Raum. Ihre Aufgabe ist es dann, sich abwechselnd mit ihrem Gegenüber über ein erfreuliches und ein ärgerliches Erlebnis aus Ihrem Leben zu unterhalten. Sie werden vor dem Gespräch genügend Zeit haben, sich an solche Situationen aus Ihrem Leben zu erinnern. Vor den Gesprächen wird Ihnen diese Aufgabe vom Versuchsleiter noch einmal genau erklärt. Ein Teil der Datenerhebung in den Gesprächen erfolgt über Videoaufnahmen der Gespräche. Da das Anfertigen von Videoaufnahmen sehr persönlich ist, bekommen Sie neben einer Einverständniserklärung zur Teilnahme am gesamten Experiment auch eine zusätzliche Einverständniserklärung speziell dafür, dass Sie uns erlauben, diese Videoaufnahmen zu machen und sie zu Forschungszwecken auszuwerten.

Außerdem sind wir auch an bestimmten psychophysiologischen Parametern interessiert, die wir direkt an zwei Stellen auf der Hautoberfläche in Ihrem Gesicht messen können: über der Augenbraue und auf der Wange. Es ist hierfür erforderlich, vier kleine Sensoren an den diesen Stellen aufzukleben. Die Sensoren werden dafür mit hautverträglichen Kleberingen bestückt und an den entsprechenden Stellen leicht angedrückt. Damit ein guter Messwert entstehen kann, müssen wir die entsprechenden Hautstellen zuvor mit einem Wattepad und einem Gel mit Peeling-Wirkung reinigen. Dies kann unter Umständen zu leichten Hautrötungen führen und die Reinigung muss mit leichtem Druck auf die Haut ausgeführt werden, so dass manche Menschen diese Prozedur als unangenehm empfinden könnten, worauf wir Sie hiermit hinweisen möchten. Natürlich gehen die Versuchsleiter hier aber so sorgsam wie möglich vor und sprechen die einzelnen Schritte mit Ihnen ab. Die Sensoren werden dann am Ende der Gespräche wieder entfernt. Die verwendete Messmethode wird weltweit vielfach angewendet und ist nach derzeitigem Wissensstand vollkommen gefahrenlos.

Im Anschluss an die Gespräche werden wir Sie noch einmal darum bitten, weitere Fragebögen auszufüllen.

Danach ist der Versuch beendet und wir stehen für weitere Fragen zur Verfügung.

Freiwilligkeit und Anonymität

Die Teilnahme an der Studie ist freiwillig. Sie können die Teilnahme an dieser Studie jederzeit und ohne Angabe von Gründen abbrechen und Ihr Einverständnis zur Teilnahme widerrufen, ohne dass Ihnen daraus Nachteile entstehen. Auch wenn Sie die Studie vorzeitig abbrechen, haben Sie Anspruch auf eine anteilige Vergütung für den bis dahin erbrachten Zeitaufwand.

Die im Rahmen dieser Studie erhobenen Daten und persönlichen Mitteilungen werden vertraulich behandelt. So unterliegen diejenigen Mitarbeiter, die durch direkten Kontakt mit Ihnen über personenbezogene Daten verfügen, der Schweigepflicht. Des Weiteren wird eine Veröffentlichung der Ergebnisse der Studie nur in anonymisierter Form erfolgen. Das heißt, dass Ihre Daten nicht Ihrer Person zugeordnet werden können.

Datenschutz

Die Aufzeichnung und Auswertung der Daten erfolgt pseudonymisiert, das heißt unter Verwendung eines persönlichen Codes und *ohne* Angabe Ihres Klarnamens. Es existiert eine Liste auf Papier, die Ihren Namen mit diesem Code verbindet. Diese Liste ist nur dem Projektleiter (Marcel Riehle) zugänglich und wird nach Abschluss der Datenerhebung bzw. der Datenauswertung vernichtet. Ihr individueller Code ergibt sich aus einzelnen persönlichen Angaben, wie z.B. dem ersten Buchstaben des Vornamens Ihrer Mutter, kann durch Sie so jederzeit erneut generiert werden und ergibt nur für Sie einen Sinn. Sie können Ihr Einverständnis zur Aufbewahrung Ihrer Daten widerrufen, ohne dass Ihnen daraus Nachteile entstehen. Sie können so jederzeit eine Löschung all Ihrer Daten verlangen. Wenn die Codierliste bereits vernichtet worden ist, kann Ihr Datensatz von unserer Seite aus nicht mehr identifiziert werden. Dann sind Sie die einzige Person, die Ihren Code kennt über den Ihre Daten identifizierbar sind. Anstelle einer kompletten Löschung der Daten können Sie jederzeit eine *Anonymisierung* Ihrer Daten verlangen. In diesem Fall würden wir Ihren persönlichen Code durch einen artifiziellen Code ersetzen, der nicht Ihrer Person zugeordnet werden kann. Anschließend sind Ihre Daten anonymisiert. Eine Löschung Ihrer Daten ist dann allerdings nicht mehr möglich. Die Daten werden zu Forschungszwecken weiter verwendet und bleiben 10 Jahre gespeichert.

Vergütung

Für die Teilnahme an beiden Terminen der Untersuchung erhalten Sie insgesamt 30€ (10€ pro Stunde) (entsprechend der aufgebrachten Zeit). Die Vergütung wird Ihnen in bar ausgezahlt. Bei Empfang des Geldes müssen Sie eine Quittung mit Angabe Ihres Namens und Ihrer Adresse unterschreiben. Alle diesbezüglichen Informationen werden völlig separat von den Untersuchungsdaten aufbewahrt.

Sie erhalten außerdem eine Kopie dieser Probandeninformation sowie vom Versuchsleiter unterzeichnete Kopien der beiden Einverständniserklärungen für Ihre Unterlagen.

Sollten Sie noch Fragen zur heutigen Untersuchung haben, bitten wir Sie, diese nun zu stellen.

Noch einmal vielen Dank für Ihre Teilnahme!

Mit den besten Grüßen,

M. Riehle

Marcel Riehle
Studienleitung

Interaction instructions for all participants

Anleitung für das Gespräch

Sie werden sich nun gleich mit einer Ihnen bisher unbekannten Person unterhalten. Hierfür sollen Sie sich an Ereignisse aus den letzten 12 Monaten erinnern, die dann das Gesprächsthema für ihre Unterhaltung sein sollen. Auch Ihr Gegenüber soll sich an solche Ereignisse erinnern. Die verschiedenen Erlebnisse von Ihnen beiden sollen dann abwechselnd Gesprächsthema Ihres Gesprächs sein.

Erfreuliches Erlebnis

Bitte denken Sie nun an ein Erlebnis aus den letzten 12 Monaten, das Sie ***glücklich*** gemacht hat oder Sie ***erfreut*** hat und das Sie einer unbekannten Person erzählen würden. Das Erlebnis sollte in einer maximal 3-minütigen Geschichte erzählbar sein. Es soll Ihre Aufgabe sein, Ihrem Gegenüber klar zu machen, wie sie sich in der Situation gefühlt haben und warum die Situation für Sie so erfreulich war. Sie selbst wählen hierbei das Thema. Folgende Themen sollen allerdings ***nicht*** in der Geschichte behandelt werden: Arztbesuche oder Krankenhausaufenthalte, Akte physischer Gewalt, oder Geschichten, in denen Menschen ernsthaft verletzt werden. Bitte nehmen Sie sich nun kurz Zeit zum Nachdenken. Wenn Sie sich an ein geeignetes Erlebnis erinnert haben, notieren Sie sich bitte auf dem Zettel vor Ihnen einen Kurztitel für das Erlebnis. Außerdem sollen Sie auf dem Zettel ankreuzen, wie positiv das Erlebnis für Sie war und welche Emotion ***die intensivste*** war, die Sie während dieses Erlebnisses hatten.

Ärgerliches Erlebnis

Bitte denken Sie nun an ein Erlebnis aus den letzten 12 Monaten, das Sie ***verärgert*** hat oder das Sie ***aufgeregt*** hat und das Sie einer unbekannten Person erzählen würden. Das Erlebnis sollte in einer maximal 3-minütigen Geschichte erzählbar sein. Es soll Ihre Aufgabe sein, Ihrem Gegenüber klar zu machen, wie sie sich in der Situation gefühlt haben und warum die Situation für Sie so ärgerlich war. Sie selbst wählen hierbei das Thema. Folgende Themen sollen allerdings ***nicht*** in der Geschichte behandelt werden: Arztbesuche oder Krankenhausaufenthalte, Akte physischer Gewalt, oder Geschichten, in denen Menschen ernsthaft verletzt werden. Bitte nehmen Sie sich nun kurz Zeit zum Nachdenken. Wenn Sie sich an ein geeignetes Erlebnis erinnert haben, notieren Sie sich bitte auf dem Zettel vor Ihnen einen Kurztitel für das Erlebnis. Außerdem sollen Sie auf dem Zettel ankreuzen, wie negativ das Erlebnis für Sie war und welche Emotion ***die intensivste*** war, die Sie während dieses Erlebnisses hatten.

Haben Sie sich nun zwei Kurztitel notiert? Bitte fahren Sie erst fort, wenn Sie sich an ein erfreuliches und ein ärgerliches Ereignisse erinnert haben. Lassen Sie sich ruhig Zeit dafür!

Ablauf

Die verschiedenen Erlebnisse von Ihnen beiden sollen abwechselnd Gesprächsthema Ihres Gesprächs sein. Wenn Sie in der Zuhörerrolle sind, dürfen Sie gerne Nachfragen stellen oder auf das erzählte eingehen – es ist nicht nötig, dass Sie sich zurückhalten, wenn Sie etwas sagen möchten. Beispielhaft können Situationen sein, wie, sich mit einer unbekannten Person zu unterhalten, die Sie gerade auf einer Party kennen gelernt haben oder mit der Sie gerade auf einer längeren Zugfahrt in einem Abteil sitzen. Die Versuchsleiter werden sich aus einem Nebenraum über ein Mikrophon mit Ihnen verständigen. Zwischen den einzelnen Gesprächsabschnitten sagen die Versuchsleiter so auch an, wenn das Gesprächsthema gewechselt werden soll und welches Erlebnis als nächstes Thema sein soll.
Wenn wir die Trennwand gleich entfernen, stellen Sie sich Ihrem Gegenüber kurz mit Ihrem Vornamen vor und besprechen Sie als erstes, ob Sie sich lieber per „Du“ oder per „Sie“ ansprechen möchten. Es wird dann in etwa zwei Minuten dauern, bis die Versuchsleiter sich bei Ihnen melden und Ihnen mitteilen, welches Erlebnis zuerst Inhalt des Gesprächs sein soll.

Scoring sheet for the events

Kurztitel für Ihr ***erfreuliches*** Erlebnis:

____

Wie ***erfreulich / positiv*** war dieses Erlebnis für Sie?

gar nicht erfreulich ○○○○○○○○○ maximal erfreulich

Welches war die ***intensivste*** Emotion, die Sie während des Erlebnisses hatten?

Angst	Freude	Traurigkeit	Ekel
Überasschung	Ärger	Neutral / Anders	

Kurztitel für Ihr ***ärgerliches*** Erlebnis:

____

Wie ***ärgerlich / negativ*** war dieses Erlebnis für Sie?

gar nicht ärgerlich ○○○○○○○○○ maximal ärgerlich

Welches war die ***intensivste*** Emotion, die Sie während des Erlebnisses hatten?

Angst	Freude	Traurigkeit	Ekel
Überasschung	Ärger	Neutral / Anders	

Willingness-to-interact scale (Coyne, 1976)

Bitte denken Sie an das Gespräch, das Sie gerade mit der anderen Versuchsperson geführt haben. Stellen Sie sich vor, es würde sich die Möglichkeit ergeben Ihr Gegenüber noch einmal wieder zu treffen. Basierend auf Ihrem Eindruck dieser Person, geben Sie bitte an, ob Sie die folgenden Dinge gerne tun würden.

Bitte kreisen Sie zu jeder Frage die entsprechende Ziffer ein.

1. **Würden Sie die Person gerne näher kennen lernen?**

1	2	3	4	5
Ja, auf jeden Fall	Ja, könnte ich mir vorstellen	Vielleicht	Eher nein, lieber nicht	Nein, auf keinen Fall

2. **Würden Sie mit der Person gerne ins Kino gehen?**

1	2	3	4	5
Ja, auf jeden Fall	Ja, könnte ich mir vorstellen	Vielleicht	Eher nein, lieber nicht	Nein, auf keinen Fall

3. **Würden Sie die Person um Rat fragen?**

1	2	3	4	5
Ja, auf jeden Fall	Ja, könnte ich mir vorstellen	Vielleicht	Eher nein, lieber nicht	Nein, auf keinen Fall

4. **Würden Sie auf einer 3-stündigen Busfahrt neben der Person sitzen wollen?**

1	2	3	4	5
Ja, auf jeden Fall	Ja, könnte ich mir vorstellen	Vielleicht	Eher nein, lieber nicht	Nein, auf keinen Fall

5. **Würden Sie die Person zu sich nach Haus einladen?**

1	2	3	4	5
Ja, auf jeden Fall	Ja, könnte ich mir vorstellen	Vielleicht	Eher nein, lieber nicht	Nein, auf keinen Fall

6. **Würden Sie die Person zu einem gesellschaftlichen Ereignis mitnehmen?**

1	2	3	4	5
Ja, auf jeden Fall	Ja, könnte ich mir vorstellen	Vielleicht	Eher nein, lieber nicht	Nein, auf keinen Fall

7. **Würden Sie gern mit der Person befreundet sein?**

1	2	3	4	5
Ja, auf jeden Fall	Ja, könnte ich mir vorstellen	Vielleicht	Eher nein, lieber nicht	Nein, auf keinen Fall

CAINS scoring sheet

CLINICAL ASSESSMENT INTERVIEW FOR NEGATIVE SYMPTOMS (CAINS): AUSWERTUNGSBOGEN

ID: _______________ DATUM: _______________ UNTERSUCHER/IN: _______________

I. MOTIVATION UND FREUDE (MAP): SOZIALES

1. Motivation für enge Beziehungen (Familie, (Ehe)Partner/in)
2. Motivation für enge Freundschaften und (Liebes)Beziehungen
3. Häufigkeit von erfreulichen sozialen Aktivitäten – letzte Woche
4. Erwartete Häufigkeit von erfreulichen sozialen Aktivitäten – nächste Woche

II. MOTIVATION UND FREUDE (MAP): ARBEIT & SCHULE

5. Motivation für Arbeit- und Schulaktivitäten
6. Erwartete Häufigkeit von erfreulichen Arbeit- und Schulaktivitäten – nächste Woche

III. MOTIVATION UND FREUDE (MAP): FREIZEIT

7. Motivation für Freizeitaktivitäten
8. Häufigkeit von erfreulichen Freizeitaktivitäten – letzte Woche
9. Erwartete Häufigkeit von erfreulichen Freizeitaktivitäten – nächste Woche

IV. AUSDRUCK UND EXPRESSION (EXP) ITEMS

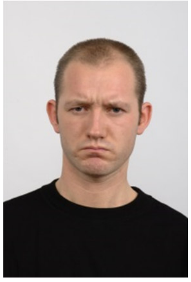
10. Mimik
11. Sprechen (Intonation)
12. Gestik
13. Sprache (Quantität)

MAP Summenscore: ___________

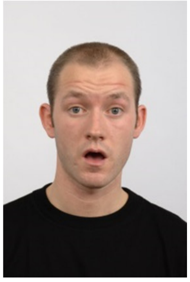
EXP Summenscore: ___________

Appendix B

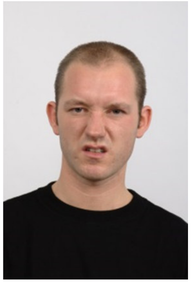
Sample sitmuli of the affect recognition test taken from the Radboud Faces Database (Langner et al., 2010)



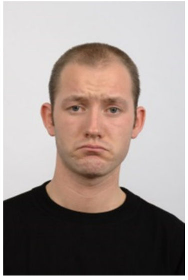
male, angry



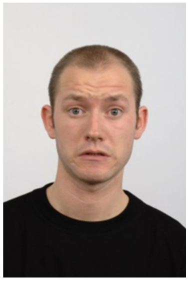
male surprised



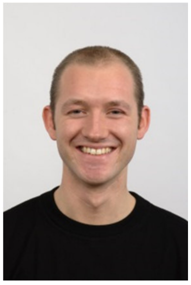
male, disgusted



male, sad



male, fearful



male, happy

male, neutral

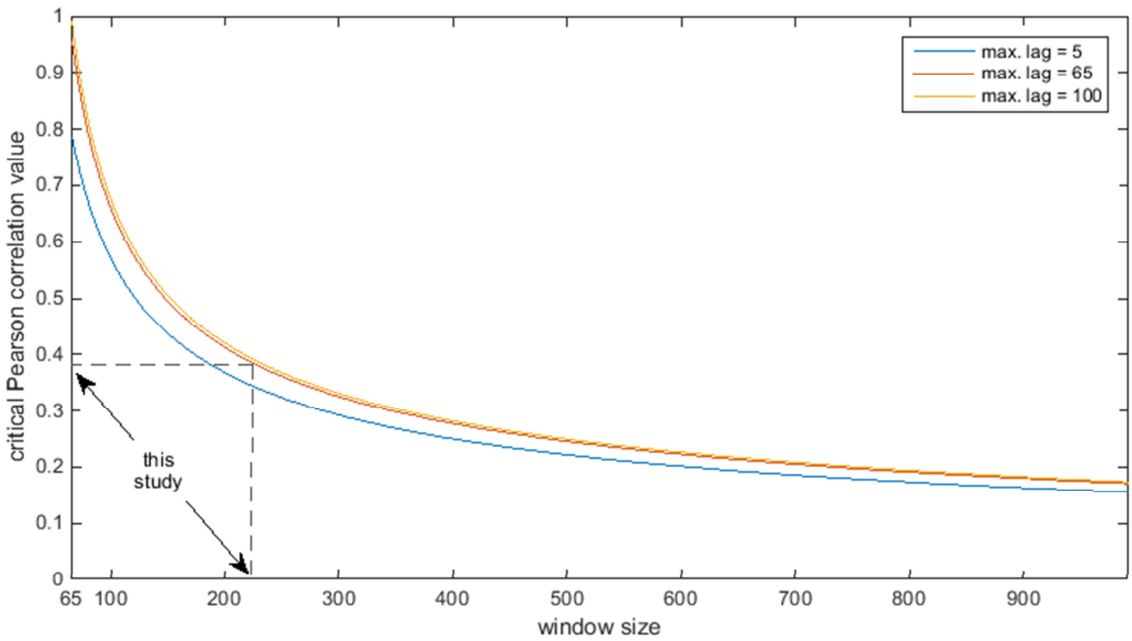
Appendix C

Additional analyses to study 1

Significance threshold

A significance threshold was used in studies 1-3 for calculated correlation coefficients to reduce the influence of smaller non-significant correlations that emerge as a result of measurement error or by chance. The threshold was set by using Bonferroni correction to adjust for multiple testing for the number of correlation coefficients calculated within a WCLC matrix. In an example WCLC analysis for a time series of 1000 observations, sampled at 50Hz, using a window length of 5s (= 250 observations) and a maximum time lag of 2s (= 100 observations), the resulting WCLC matrix would consist of 201 columns and 749 rows (cf. Boker et al., 2002). Thus, 150,549 correlation coefficients would be calculated. This leads to a significance threshold of $p_{adj} \approx .0000003$, when originally testing at an α-level of $p < .05$. Therefore, correlation coefficients would have to exceed a threshold of $r_{crit} \approx .34$. Note, that the degrees of freedom used for setting the threshold are bound to the numbers of data points within a window (in this example = 250 observations). For this reason, using the significance threshold is only advised when at least roughly 100 observations can be used as the window size, since the significance threshold is likely to asymptotically reach a value of 1 otherwise (cf. Figure S1).

The figure shows the distribution of critical Pearson correlation values of the significance threshold alongside varying window sizes for a WCLC analysis on a 3 min data sequence, sampled at 32 Hz (matching study 1; in total 5760 data points). The different lines represent different maximum time lags (study 1 used a window size of 224 and a maximum lag of 64). Note: max. lag = maximum time lag; numbers for window size and max. lag refer to numbers of observations.

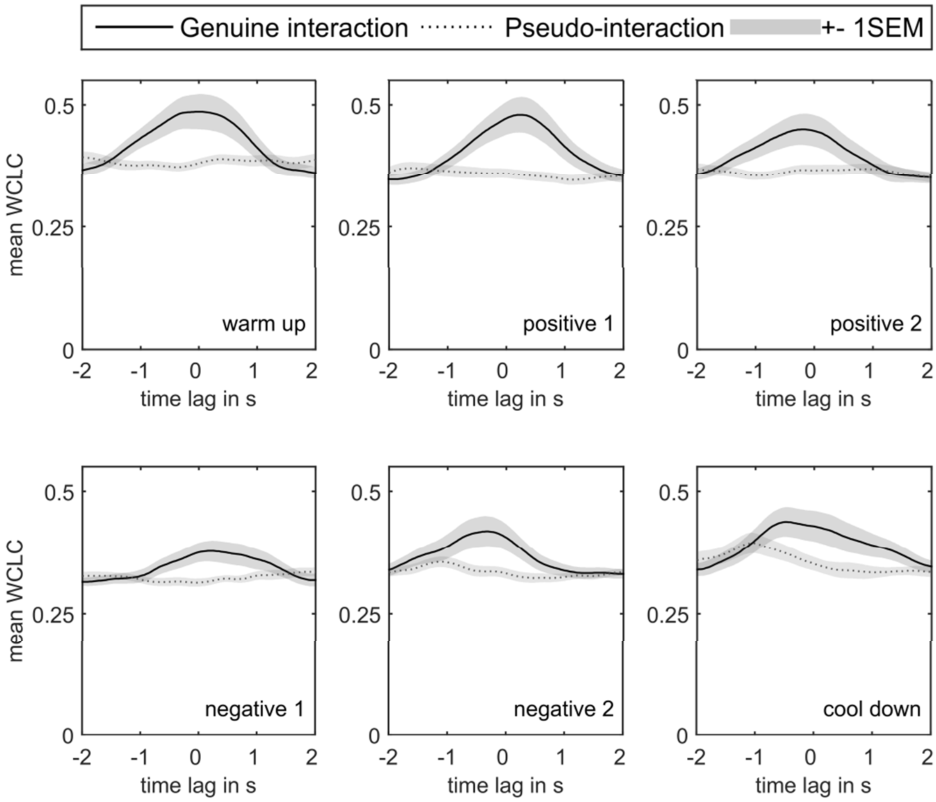


Comparing WCLC with and without constraints

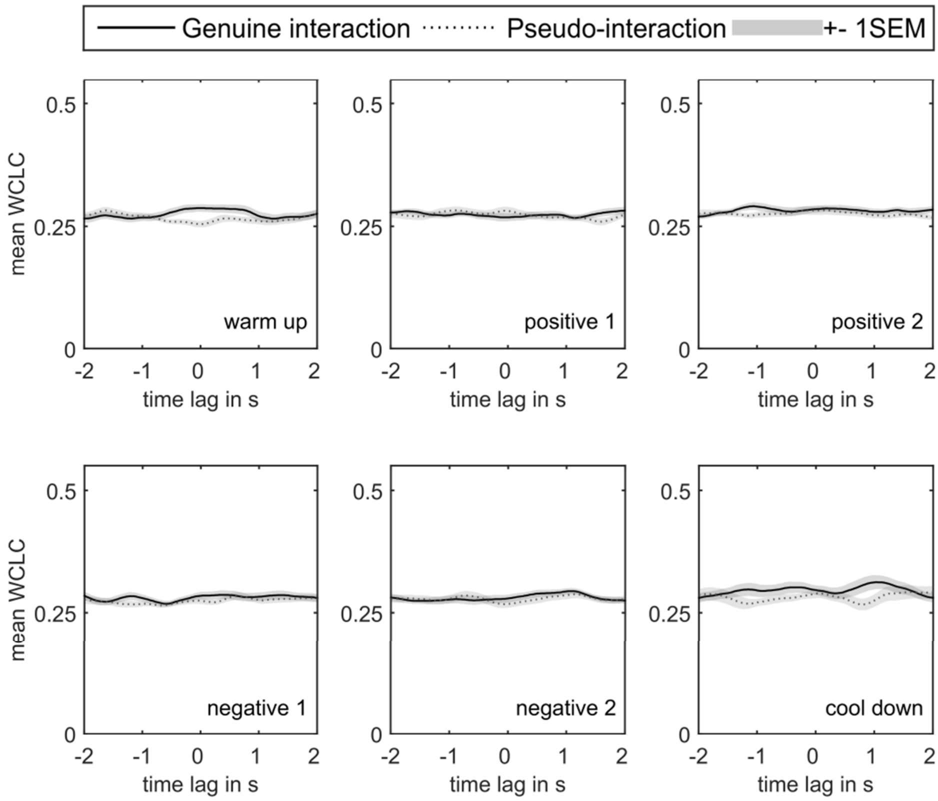
In an intention to compare the approach employed in studies 1-3 and the approach used by Ramseyer and Tschacher (2011) more directly, the WCLC synchrony was also calculated without significance threshold and without excluding absolute values of negative correlations. The same three-way repeated measures ANOVA as described in study 1 (muscle site by interaction type by (interactional) phase) was run on the unconstrained WCLC values.

The results showed significant main effects of muscle site ($F(1,29) = 110.0$; $p < .001$; *partial* $\eta^2 = .79$), interaction type ($F(1,29) = 13.8$; $p = .001$; *partial* $\eta^2 = .32$), and phase ($F(1,29) = 8.5$; $p < .001$; *partial* $\eta^2 = .23$). Significant interactions were found for muscle site by interaction type ($F(1,29) = 6.6$; p = .02; *partial* $\eta^2 = .19$) and muscle site by phase ($F(1, 29) = 15.1$; $p < .001$; *partial* $\eta^2 = .34$). Smiling (cf. Figure S4) but not frowning synchrony (cf. Figure S5) in genuine interactions could be distinguished from chance level synchrony (pseudo-interactions). Paired samples t-tests confirmed this differential effect for all of the six interactional phases (smiling: ts(29) = 2.32–3.35; ps = .002–.03; *Cohen's d*s = 0.38–0.66; frowning: ts(29) = 0.06–1.76; ps = .09– .95; *Cohen's d*s = 0.00–0.16).

Thus, the overall effects were comparable using an approach with and without significance threshold plus omitting negative correlations. However, the mean noise-levels were higher in the unconstrained WCLC analysis and signal-to-noise ratio was considerably lower. This favors the usage of a significance threshold as well as omitting negative correlations from the WCLC matrix.



Distribution of mean Zygomaticus (smiling) mimicry unconstrained WCLC estimates for the along the different time-lags for each interactional phase for both genuine (solid line) and pseudo-interactions (dotted line). The shaded gray areas represent ±1 standard error of the mean.



Distribution of mean Corrugator (frowning) mimicry unconstrained WCLC estimates for the along the different time-lags for each interactional phase for both genuine (solid line) and pseudo-interactions (dotted line). The shaded gray areas represent ±1 standard error of the mean.

Appendix D

Additional analyses to study 3

Mood monitoring

The valence and arousal changes as captured with the SAMs were compared for the two participant groups (SZ and HC) in a repeated measures ANOVA with the two within-subjects factors time (arrival/baseline vs. before the interaction vs. after the interaction) and group status (SZ vs. HC).

A significant main effect of group emerged for valence ($F(1,24) = 5.24$; $p = .03$) and for arousal ($F(1,24) = 11.37$; $p = .003$). SZ participants presented with less positive valence and higher arousal. Additionally, a significant main effect of time emerged both for valence ($F(2,48) = 20.03$; $p < .001$) and arousal ($F(2,48) = 17.65$; $p < .001$). Post-hoc pairwise comparisons revealed that for valence, the participants indicated significantly more positive mood after the interaction than at both assessment points prior to the interaction. For arousal, the participants indicated significantly less arousal after the interaction than at both assessment points prior to the interaction. Additionally, there was a trend towards an increase of arousal from arrival to directly before the interaction. Both group*time interactions were non-significant, indicating that SZ and HC participants reacted to the interaction “stressor” in a similar way.

Exclusion of dyads with somewhat disclosed patient status

The hypotheses tests of study 3 were performed again after excluding the two cases that somewhat disclosed their patient status during the interaction.

1. Paired samples t-tests for differences for SZ > HC participants

Dependent	*t* (*df* = 24)	*p*	d_z
WILL	-2.63	.02	-0.47
Zygomaticus activity	-0.35	.73	-0.06
Corrugator activity	-2.09	.05	-0.42
Zygomaticus mimicry	-1.73	.10	-0.29

The results equal those in study 3. However, in this analysis, a marginally significant effect of less Corrugator activity emerged, whereas in study 3 this effect was non-significant. Also, a marginal trend-level significant effect for less Zygomaticus mimicry emerged, when excluding the two patients who somewhat disclosed their patient status.

2. Affect recognition predicting Zygomaticus (smiling) mimcry

The parameter estimates did not change in a meaningful way by excluding the two triplets from the analysis. For patients, again there was no relationship (β = .24, p = .22) and for healthy controls there was a highly significant relationship (β = .58; p < .001).

3. Smiling behavior predicting IP's WILL scores

The results changed slightly in that the prediction within the patient sample was slightly higher in magnitude (β = .88; p = .01) and for healthy participants was no longer trend-level significant (β = .36; p = .13)