Physiological synchrony in the context of cooperation: Theoretical and methodological considerations
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Chapter 6

General discussion

Human cooperation is an incredible phenomenon that comes in many forms including two to thousands of individuals, from a single occasion to multiple across decades, from carrying a heavy wardrobe up the stairs to international collaborations, and from infancy to adulthood. How can cooperation succeed on so many different levels? The current thesis investigates the role of nonverbal communication in successful cooperation and how such link can be most reliably tested in the lab. Specifically, in two chapters I demonstrate how face-to-face interactions can boost cooperation between strangers. Additionally, I place the tasks I use to measure cooperation into the broader context of prosocial behavior and zoom in on how to statistically capture the strength of synchrony between interaction partners. In the following, I start by summarizing the main findings from the studies presented in Chapter 2 to 5 and subsequently discuss their theoretical and methodological implications before I close up with concluding remarks.

Summary of the main findings

In **Chapter 2**, I presented a study where I aimed to investigate whether economic games and more naturalistic, interactive games measure similar behavioral tendencies, that is, prosociality. To test this, 74 participants played six different prosocial behavior tasks in a within-subject design. In dyads, participants played three variants of a social dilemma game: the original and an extended version of the Prisoner's Dilemma game (extending the response options from two to six), and a Rope-Pull game (based on the same principles as the classical Prisoner's Dilemma game, but requiring less cognitive abilities). Additionally, participants played an Egg-Hunt game (people could help another participant to collect more Eastern eggs), the Hidden-Profile game (participants needed to exchange information to make the correct decision), and a Tangram game (participants completed puzzles together). A Principle Component Analysis showed that behavior across these tasks was best captured by two components termed "social dilemma games" and "naturalistic games". The three variants of the social dilemma game loaded positively on the first component. Behavior in these games was distinct from behavior in the more naturalistic games. This finding demonstrates that the behavioral consistency observed in previous studies using economic games does not generalize to more ecologically valid games. The Egg-Hunt game loaded positively and the Hidden-Profile task loaded negatively on the second component. In other words, the more eggs a person collected for their partner during the Egg-Hunt game, the less information s/he shared during the Hidden-Profile game. One possible explanation for this finding is that people shared their information in an attempt to convince their partner of their own opinion, reflecting selfish behavior and therefore showing a negative correlation with helping behavior in the Egg Hunt game. Regarding the "social dilemma games" component, the finding that the original and extended Prisoner's Dilemma game clustered together was particularly relevant as I used these games to measure cooperation in Chapter 3 and 4, respectively. The fact that they clustered together supports the idea that they tap into similar behavioral tendencies. This is crucial because the aim of extending the classical Prisoner's Dilemma game was to preserve the same principle of the game and measure similar behavioral tendencies, while only changing the scale of the measure.

In **Chapter 3**, I investigated the beneficial effect of nonverbal communication on cooperation and how it is affected by past experience with the interaction partner. To that end, two participants ($N = 116$) played multiple rounds of the Prisoner's Dilemma game. During some rounds, participants could see each other, while during other rounds a visual cover between them prevented nonverbal communication. Additionally, dyads received either no, correct, or random (50% incorrect) feedback about each other's decisions after each round. Our results revealed that these two sources of information operated independently: face-to-face contact promoted cooperation and knowing the partner's previous decisions increased cooperation, but these two types of information would not strengthen or weaken their individual effects on cooperation. Even if the participants heard that their partner acted selfishly in the previous round, the beneficial effect from seeing each other still worked. In other words, face-to-face contact had a robust effect on cooperation, even if a person could not verify that the interaction partner reciprocated the cooperative act or if the other person had been selfish before.

In order to explain why face-to-face interaction has such positive effects on cooperative behavior, I investigated physiological synchrony as a potential underlying mechanism in **Chapter 4**. To investigate the involvement of this mechanism, I tested 152 participants in a similar set-up as the previous study with two differences: (1) throughout the experiment, participants' physiological responses were measured (i.e., heartrate and skin conductance level) and (2) the payoff structure of the Prisoner's Dilemma game changed from a 2×2 to a 6×6 structure (both versions of the game measure similar behavioral tendencies as shown in Chapter 2). Results showed that physiological synchrony emerged during social interactions and that it was related to the cooperative success of dyads. Interestingly, although physiological synchrony developed for both heartrate and skin conductance level, only the latter showed the predicted beneficial effect on cooperation. This indicates that aligning each other's responses on the sympathetic level was particularly important for how well two individuals worked together.

In the last study presented in **Chapter 5**, I dove deeper into the methodological challenges of properly quantifying interpersonal synchrony. I refined an existing analysis that was developed by Boker et al. (2002) and that I applied in Chapter 4, by tailoring its parameter settings to four physiological responses in a new dataset ($N = 68$). Specifically, I systematically investigated the effects of a range of parameters on how well the method could discriminate real dyads from people who were artificially paired into dyads but never actually interacted (i.e., surrogate dyads). I observed that the choice of parameters influenced the ability to distinguish the original dyads from the surrogate dyads and that similar patterns in parameters emerged between signals pinpointing to an intrinsic characteristic of the method. Nonetheless, the best choice of parameters differed between physiological measures as they should be tailored to the time course of the (component of the) signal of interest. Based on these considerations, I developed guidelines for each physiological measure to increase the comparability of research findings across studies.

Up until now, this dissertation has followed the order of studies starting from a board perspective and then zooming in more and more on specific aspects of the previous study. With such an approach I aimed to answer the questions of how nonverbal communication between individuals affects cooperative success and how it can be best investigated in the lab while safeguarding ecological validity. While Chapters 3 and 4 answer the first question with mainly theoretical implications, Chapters 2 and 5 address the second question which concerns predominantly methodological challenges. In the following, I will discuss the implications of the main findings in light of this distinction: theoretical and methodological implications.

Theoretical implications

The main theoretical question of the current thesis concerns how nonverbal communication affects cooperative success. In the first study (Chapter 3), I replicated previous studies showing that access to nonverbal communication is beneficial for cooperation. I extended such finding by demonstrating the robustness of the effect: face-to-face contact boosts cooperation to a similar extent if a person has past experiences with another person, or if she has no explicit knowledge. Of course, receiving information about another person still strongly influences people's willingness to cooperate. As outlined in Chapter 1, knowledge about other people's behavior facilitates the prediction of future behavior and provides a straightforward way to verify whether the prediction was accurate and whether that person can be trusted during future encounters. In a similar vein, nonverbal communication provides information about a person's intentions which facilitates the prediction of that person's next decision. Contrasting our expectations, these two sources of information operated independently on cooperation. Face-to-face contact can even "overrule" the urge to reciprocate a selfish act. In other words, our study suggests that nonverbal communication boosts cooperation to a certain degree and that that degree is constant independent of how much and what a person knows about the other individual.

The question of *how* face-to-face contact exerts its positive effects on cooperation was the focus of Chapter 4. As outlined in Chapter 1, researchers have proposed that humans have developed a refined signaling system of intentions where a variety of explicit and implicit signals facilitates nonverbal communication in social interactions (Boone & Buck, 2003). Additionally, our own emotions and their associated changes in inner states influence our decision-making (Damasio et al., 1996; Loewenstein & Lerner, 2003). Both approaches focus on how intrapersonal changes in either the observer or the observed are perceived. However, when moving from individuals' willingness to dyadic success of cooperation, I show that the signaling system incorporates an interpersonal, dynamic back-and-forth component. In fact, looking at implicit responses on the intrapersonal level was not informative of cooperative success. Instead, the study demonstrates that it is that extra layer of interpersonal communication that emerges over and above the individuals' responses during social interactions that determines how well individuals within dyads work together.

Similar to the intrapersonal level, interpersonal communication incorporates a range of different signals apparent on the explicit and implicit level. In the current thesis, I focused on two physiological responses, heartrate and skin conductance level. Other studies have shown that other types of synchrony also influence prosocial behavior such as facial mimicry, movement and vocalization synchrony (for reviews, see Mogan, Fischer, & Bulbulia, 2017; Palumbo et al., 2017; Prochazkova & Kret, 2017; Rennung & Göritz, 2016). This makes sense for two reasons: (1) given the subtle nature of physiological responses, synchrony on such level must emerge through other visible signals and (2) the more (explicit and implicit) expressions are synchronized, the better ambiguous expressions can be interpreted and the better a person can feel herself into the other person. Regarding the first reason, I observed that when people aligned their arousal responses reflected in skin conductance level changes, they were more successful to cooperate. Changes in skin conductance level are not directly visible to other people. Thus, the associated changes in arousal must be reflected in other, visible cues. This is also supported by the finding that synchrony increased with face-to-face contact compared to when a visual cover prevented nonverbal communication. In Chapter 4, I argue that pupil dilation and blushing might be potential cues as they are linked to changes in skin conductance and heartrate (Bradley et al., 2008; Dijk et al., 2011; Voncken & Bögels, 2009). In other words, people need to attend and possibly synchronize with other signals in order to reach the synchrony on the implicit, physiological level.

With respect to the second reason, our emotions and intentions are reflected in a range of explicit and implicit expressions. One expression can be interpreted in different ways depending on the context in which the expression is displayed and the combination with other expressions. For example, a smile can signal, among other states, subordination (Hecht & LaFrance, 1998), seeking of approval (Cashdan, 1998), or expressing embarrassment (Goldenthal, Johnston, & Kraut, 1981). One way to reduce the ambiguity and thereby helping to infer the meaning of a smile is to look at other signals complementing that smile. For example, expressing embarrassment is likely to be accompanied by blushing. Not only observing, but also synchronizing these different expressions can help to emotionally align with the person which subsequently affects behavior towards that person (Preston & de Waal, 2002). From this it can be argued that the richer the representation of another person's inner state through synchronization of different expressions, the stronger the emotional contagion and the more pronounced the potential effect on subsequent (prosocial) behavior. It is therefore likely that, although I only measured physiological measures, individuals synchronized on multiple levels. Following this argumentation, the answer to my research question of how nonverbal communication affects cooperative success is that we rely on a complex interpersonal signaling system incorporating different behavioral and physiological components that, when integrated, facilitates prosocial behavior towards one another.

Methodological implications

The second question the current thesis aims to answer is how we can best measure the link between nonverbal communication and cooperation in the lab from a methodological perspective. Specifically, in Chapter 2 I addressed the question of *what* we measure in light of how different prosocial behavior tasks address similar or distinct behavioral tendencies. In Chapter 5, I scrutinized the question of *how* we measure physiological synchrony. Here, I refined the method of how to optimally quantify physiological synchrony which forms the basis to investigate its causes and consequences and to compare findings between studies. In the following, I will discuss the methodological implications of these two studies with regard to the theoretical findings presented above.

In Chapter 3, I used the Prisoner's Dilemma game to measure cooperative behavior. In the follow-up study presented in Chapter 4, I changed the game from a dichotomous choice to a six-point scale, aiming to capture more fine-grained changes in cooperation. Despite this change, the two versions should still tap into the same behavioral tendencies, which was crucial as I investigated the underlying mechanisms of the effects observed in Chapter 3 in Chapter 4. Integrating the findings of both chapters with the results presented in Chapter 2, I am confident that this was indeed the case for two reasons. First, I demonstrated that behavior in these two versions were correlated suggesting that people who cooperated in one version also cooperated in the other version. Second, the cooperation rates observed in Chapter 2 were comparable to the rates seen in Chapter 3 and 4 for the original and extended version, respectively. Such consistencies support the choice of using the social dilemma games in both studies as a measure of cooperative behavior. In a next step, it is crucial to investigate whether the effects observed in Chapter 3 and 4 also generalize to more ecologically valid settings. The findings presented in Chapter 2 suggest that such generalization is challenged by methodological issues that come into play when moving away from the controlled setting of the economic games. Factors such as individual differences in skills to complete a task, ambiguity in the motivation behind behavior, and differences in the clarity of how to act prosocially are likely to influence the behavior displayed in a game. These methodological issues should not refrain researchers from studying synchrony in real life settings. In fact, our lab has successfully studied the influence of physiological synchrony in a blind-date experiment that we conducted during a festival (Prochazkova et al., 2019). However, the behavior of interest might be noisier and researchers need to take into account these differences when choosing a paradigm for their study and when comparing results between studies using different paradigms.

Moving the focus away from measuring cooperation to synchrony, one essential question is how strongly results on synchrony are influenced by the way it is quantified. Variations can originate from differences within and between methods. In Chapter 5, I focused on within-method variations and investigated how parameter settings within the Windowed Cross-Correlation analysis can cause such variation. In short, the method segments the time series of two interacting individuals into smaller, overlapping segments, also called windows, and calculates the cross-correlation between each segment. Additionally, for each segment the two time series are shifted away from each other up to a maximum lag. The size of the window and the maximum lag are two parameters that have been shown to influence the estimation of synchrony (Robinson et al., 1982; Schoenherr et al., 2019). In Chapter 5, I investigated the effect of the two parameters in the context of four physiological responses. I observed great variations between parameter configurations with a general pattern apparent in all signals: smaller window sizes were generally better in detecting synchrony. Nevertheless, there was a range of values that showed that ability, leaving the decision on which parameter to use to theoretical considerations. Regarding the maximum lag, the results revealed that this parameter was less influential than the window size, yet not trivial. The optimal maximum lag was around twice the window size. Based on these findings and theoretical considerations, I provide general recommendations on setting the window size and the maximum lag. However, I could not provide concrete optimal values for both parameters, leaving this choice to the researcher. Importantly, rather than searching for that one-fits-all solution, setting the window size to a specific value should be seen as testing a hypothesis, namely, whether people synchronize their responses that are equal to or longer than the window size chosen. In other words, different parameter choices constitute different hypotheses. Consequently, it is crucial that the researchers specify their choices both in the hypothesis and conclusion.

How can these conclusions be integrated with the results presented in Chapter 4, where I used this WCC analysis to quantify synchrony? In Chapter 4, I chose a window size (8 seconds) that falls in the range of appropriate values based on the results presented in Chapter 5. However, it is important to note that I did not apply the same surrogate data analysis in Chapter 4. Instead, I performed a down-graded version of the surrogate data analysis, where I compared the original dyads to one iteration of newly generated dyads rather than every possible dyad combination (see Chapter 4 for an explanation). As both variants are based on similar principles, I would expect similar results. Nevertheless, the surrogate data analysis allows for stronger conclusions because the level of pseudosynchrony can be estimated more reliably with a distribution of random dyads compared to one random dyad. Albeit less sensitive, the down-graded analysis performed in Chapter 4 was still sensitive enough to distinguish between the original and random dyads with the parameters chosen.

The choice of two other parameters might have undermined the effects presented in Chapter 4, in particular the maximum lag and the window increment. While the window size was 8 seconds, the maximum lag was 4 seconds. In Chapter 5, I recommend using a maximum lag of at least the size of the window. Therefore, the maximum lag used in Chapter 4 is half the recommended size. Additionally, I recommend using a window increment that is 1–5% of the window size. Therefore, for the analysis performed in Chapter 4, an increment of 80 – 400ms would have been preferred over the 2 seconds increment I used. Although the parameters chosen in Chapter 4 are not incorrect, the relatively small maximum lag and the relatively large increment result in a less sensitive analysis. With respect to the maximum lag, responses that lied further apart from each other than 4 seconds were not detected, potentially missing some moments of synchrony. This is especially the case for skin conductance level because it is a slow signal and therefore responses to one another might have lied further apart than 4 seconds. Still, there were sufficient responses that occurred within the 4 second range because the level of synchrony was higher in the original compared to the surrogate dyads. However, our results most likely showed conservative levels of synchrony, assuming that synchronized responses that lie further apart are not qualitatively different. Similarly, the relatively large window increment causes less overlap between two window segments. Consequently, the resolution of how the level of synchrony changes over time was lower, potentially missing subtle, yet crucial changes. Importantly, I would like to stress that all of this is not to say that the chosen parameters were incorrect. Instead, I would like to note that I might have missed subtle changes and consequently computed conservative estimates of synchrony. Assuming that these subtle changes would have provided only more rather than qualitatively different information, I might have obtained stronger effects in Chapter 4, if I had used the parameter recommendations of Chapter 5, but not completely different results.

In Chapter 4, I was mainly interested in the change in synchrony between two conditions and its link with cooperative behavior. The ability to detect such change in synchrony was also the aim of the study presented in Chapter 5. Unfortunately, the results lacked clear patterns across parameter configurations and showed inconsistencies between the primary and replication analysis. Such inconsistencies could have been the result of an unsuccessful manipulation between the two conditions and little differences between parameters, or the WCC analysis method that was not sensitive to detect changes that were in fact there. The results presented in Chapter 4 support the former explanation because I observed clear differences in conditions with parameters included in the range of parameters investigated in Chapter 5. Thus, in Chapter 4 the method was sensitive to detect change in synchrony. Further in line with the argument that the manipulation in Chapter 5 might not have been sensitive enough is the fact that the manipulation in Chapter 4 might have been indeed stronger as people could either see each other, allowing for nonverbal communication, or were prevented from nonverbal communication by means of a visual cover between participants. On the other hand, participants could always see each other in the study used in Chapter 5, either engaging in storytelling or looking at each other in silence. Thus, only changing the way participants interacted instead of manipulating *whether* they could interact or not might explain the small differences between conditions across parameter configurations. However, this interpretation is speculative and further research is needed on the sensitivity of parameter configurations to detect changes in synchrony.

Chapter 5 shows great variation in the strength of synchrony estimated by the same method with different parameters. Given such deviations *within* one statistical analysis method (Windowed Cross-Correlation analysis), it is likely that the differences are even more pronounced *between* statistical analysis methods. As a consequence, the comparability between studies that use different methods is likely to be low. The few studies that have looked into physiological synchrony and its link with cooperation indeed used different methods and show equivocal findings with demonstrating either increased heartrate synchrony, or elevated skin conductance level synchrony, or no link at all in a cooperative compared to a competitive context (Chanel et al., 2012; Järvelä et al., 2014; Mitkidis et al., 2015; Mønster et al., 2016; Vanutelli et al., 2017). For example, while some researchers applied a (multivariate) recurrence quantification analysis (Mitkidis et al., 2015; Mønster et al., 2016), others used slightly varying forms of simple cross-correlations and additionally calculated a weighted coherence measure of the frequency domain (Chanel et al., 2012; Järvelä et al., 2014; Vanutelli et al., 2017). These methods address different questions, have different assumptions, and operationalize synchrony in different ways. I do not mean to say that one method is better than the other, but it is important to realize that they measure different aspects of synchrony which might explain the equivocal findings in these studies.

Schoenherr et al. (2018) compared seven linear time series analysis methods (TSAMs) with different outcome scores and observed that they could be divided into three correlated, yet distinct facets of synchrony: the strength of synchrony of the total interaction, the strength of synchrony during synchronization intervals, and the frequency of synchrony. The WCC analysis as applied in the current thesis measured the first component. The reason for choosing a measure for the total interaction rather than identifying intervals of synchrony first is that I used continuous measures without clear moments of activation and deactivation. The strength of synchrony will certainly vary over time, however, not to the extent that it is on or off as can be the case, for example, in motor movements. A head or hand can move or not; a heart does not stop beating in between. For the facial expression measure, determining the synchrony intervals could have been an option. However, I wanted to be consistent across measures and for the other three signals taken under the loop in Chapter 5, it seemed most appropriate to consider the whole interaction. One could, of course, still apply a certain threshold to classify synchrony intervals as performed in the peak-picking algorithm developed by Altmann (2011). This option has been suggested to be particularly interesting for linking moments of high synchrony to specific characteristics of a conversation (Schoenherr et al., 2018). However, it is important to realize that investigating how *strong* people synchronize is a different question than how *often* they do so, and that the outcomes of these analyses are likely to be different. This comparison considers two analyses that could be considered cousins given the partial overlap in procedures (Windowed Cross-Correlation and Windowed Cross-Regression analysis; Altmann, 2011; Boker et al., 2002). Other methods concentrate on the association between participants' responses in nonlinear patterns or in the frequency domain, addressing yet other questions. It is beyond the scope of this thesis to provide an overview of these different methods and I would like to refer the interested readers to other literature (Gates & Liu, 2016; Lee-Helm, Miller, Kahle, Troxel, & Hastings, 2018; Schoenherr et al., 2018; Thorson, West, & Mendes, 2018). The important lesson here is that researchers should carefully consider different methods and be aware of what exact research question they answer with a given analysis. Once they have decided on the method, they should carefully choose its appropriate settings. Chapter 5 takes a step into this direction by providing recommendations on how to apply the WCC analysis to multiple physiological measures.

In summary, in this section I discussed two methodological implications when studying the link between nonverbal communication and cooperative behavior. First, I looked into how the finding that more synchronized dyads are more successful in cooperation could be generalized to more naturalistic games. Integrating the findings presented in Chapter 2, I encourage researchers to use more ecologically valid games and investigate whether our findings could be generalized to these situations. At the same time, I pinpoint to the methodological challenges encountered when moving away from the controlled economic games that should be considered when choosing a paradigm for a study and when comparing findings between studies using different games. Second, I discussed the implications of how synchrony is quantified with different analyses and different settings within an analysis. Researchers are faced with a great amount of (correct) choices emphasizing the need to clearly specify their choices in both their hypotheses and conclusions. I hope that the studies presented in Chapter 2 and 5 will guide researchers in making well-informed decisions which will increase the comparability across studies and shed more light on the link between nonverbal communication and interpersonal processes.

Limitations and (new) open questions

As already highlighted in the "theoretical implications" section, synchrony most likely happens on a wide range of behavioral and physiological levels. Here, I focused on two physiological measures, looking at only one piece of the puzzle. Future research is needed where multiple, both explicit and implicit measures, are measured simultaneously to address questions such as "What are the channels through which physiological synchrony emerges?", "How are different signals integrated into making a decision to cooperate or not?", "Are some signals more synchronized and more important drivers for making a cooperative decision than other signals?", "Is the number of synchronized expressions crucial for how strong their (joint) effect is on cooperation?", "Are the effects of different expressions and their integration similar across other (pro-) social behaviors?". Conducting studies where multiple signals are measured simultaneously could provide valuable insight into these questions.

The current thesis concentrates on the link between synchrony and cooperation, and discusses the implication for other prosocial behaviors. However, prosocial behavior is only one example that has been linked to synchrony. Other interpersonal processes such as sexual attraction, marital satisfaction and therapeutic outcomes have also been shown to be affected by synchrony (Levenson & Gottman, 1983; Prochazkova, Sjak-Shie, Behrens, Lindh, & Kret, 2019; Ramseyer & Tschacher, 2011). Is the link between synchrony and these different interpersonal processes caused by similar underlying processes? What other effects could synchrony have that subsequently affect the way individuals behave towards one another? Future studies are needed where the link between synchrony and social behavior is investigated further in terms of the underlying mechanisms. Given that it is unlikely that each such link is tight to one specific process, including multiple measures in one study can help us disentangle the function of synchrony on different social behaviors.

Another crucial question that remains unanswered is whether synchrony is a cause or consequence of cooperation. In other words, does the emergence of synchrony between two individuals affect how well they subsequently work together or is the strength of synchrony a reflection of how well they have cooperated? In the literature, this question is reflected in two lines of research, either manipulating synchrony or the prosocial setting. The former has concentrated on motor and vocalization synchrony asking people to dance, tap, or sing together and investigate how prosocial behavior changes between synchronized and non-synchronized conditions (for two meta-analyses, see Mogan et al., 2017; Rennung & Göritz, 2016). Another related line of research focuses on how blocking facial mimicry impairs emotion processing, for example, in response to Botox treatment and in clinical populations such as the Möbius syndrome (Bogart & Matsumoto, 2010; Neal & Chartrand, 2011). Although not directly addressing social behavior, it sheds light on how social interactions are affected by the lack of synchrony which can subsequently affect behavior. In the context of physiological synchrony, manipulating the level of synchrony in, for example, heartrate is less straightforward, which is why research has focused on manipulating the cooperative setting and investigating its effect on synchrony. Given that manipulating both variables affect the other suggests that the relationship is bi-directional. In line with the Perception-Action Model (Preston & de Waal, 2002), in my dissertation I adhere to the perspective of studying synchrony as a potential underlying mechanism for why face-to-face contact boosts cooperation. Such directional effect is reflected in the study in Chapter 4 where people first look at each other, allowing for nonverbal exchange of information, and subsequently make a decision to cooperate. Thus, synchrony precedes the decision to cooperate. However, given the repeated nature of the design with participants playing multiple rounds in succession, it is possible that the reported effects are influenced by carry-over effects between rounds mirroring reflections rather than antecedents of cooperation. Future studies should elucidate on the question of the causal link between synchrony and cooperation.

Finally, I want to emphasize the importance of conducting real-life interaction studies. Cooperation is a social concept and should therefore ideally be treated as such. This entails investigating cooperation in actual interactions, moving away from one-person computerized paradigms. Although these paradigms provide researchers with great experimental control, they undermine the interpersonal processes observed in the current thesis. I took a step in that direction by letting two participants interact during the study. However, the setting was still controlled and performed in the lab, compromising the ecological validity of the findings. Therefore, future studies should investigate whether the observed effects between physiological synchrony and cooperation are also visible outside the lab and pass the test of practical relevance (for instance, see Prochazkova et al., 2019 for a study conducted at a festival where physiological synchrony predicted blind-date success).

Conclusions

Large-scaled cooperation has been suggested as one of the driving forces of human's superiority in the evolutionary hierarchy. Its success depends on individuals working together and thereby relies on how these individuals connect on a subtle, unconscious level of nonverbal communication. Despite the technical advances that globally connect human society on a hereto unknown scale, technology cannot replace the deep-wired, evolutionary drives to communicate and bond with other individuals on the biological level for which face-to-face interactions are so essential. The current thesis sheds light on what that nonverbal communication entails revealing a new layer of interpersonal back-and-forth communication that is more than the sum of the responses of the interacting individuals. Through face-to-face contact, people pick up subtle changes of arousal in their interaction partner and adjust their own arousal levels accordingly. This connection of two bodies, emerging outside our control and consciousness, influences how well we cooperate with each other. Alongside these great theoretical implications, I have embedded these findings in a methodological cushion. First, the finding that physiological synchrony is associated with cooperation should not be blindly generalized to more naturalistic paradigms of prosocial behavior without further investigation. Therefore, researchers need to know *what* they measure. Finally, zooming in on how to statistically capture the strength of synchrony between individuals, I emphasize that researchers need to know *how* they measure it.