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

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Summary

Cooperation is of great importance in our society and an essential ingredient for the success of humanity. While the news is often filled with horrific misdeeds committed by humans, there are just as many examples of unimaginable acts of cooperation and goodness. People are willing to donate money to people they will never meet, research projects are set up with researchers living on the other side of the world, and dozens of countries are currently fighting together to get the corona virus under control. In this thesis I investigate the question of how nonverbal communication influences how well people work together and how this can best be tested in the lab. The four empirical studies presented build upon each other by holding a magnifying glass over one aspect of the previous study.

The first study discussed in **Chapter 2** describes a methodological paper where I compare tasks (or "games") that measure prosocial behavior in different ways. These tasks have all been used to measure cooperative behavior in the lab. Three of them are so-called social dilemma tasks, where a dilemma is created between the interest of an individual and that of the group by means of simple rules to distribute resources between people. The other tasks are closer to life outside the lab, where participants collect Easter eggs, discuss which candidate is the best fit for a job, and solve puzzles together. By comparing the two types of games, I was able to investigate whether the games measure the same behavior and are therefore interchangeable between studies. The results show that this is not always the case. People who cooperated with others in the social dilemma tasks did not show more prosocial behavior in the more naturalistic games. This difference is best explained by differences in how good people were in a game (e.g., how well they can solve puzzles) and how clear it was *whether* and *how* people could work together. In other words, just like in real life, it was not always a question of wanting to act prosocially, but also of being able to do so. Importantly, I was able to demonstrate that two versions of the social dilemma tasks do measure the same behavior, because I use these tasks in the following chapters to measure cooperative behavior. The only difference between the tasks was that in one version people could choose between working together or not and in the other version they could choose from six options that represented a kind of "scale of wanting to work together".

In **Chapter 3**, I zoom in on cooperative behavior and look at what makes people succeed in working together. One important ingredient is that people not only make verbal or written agreements with each other, but look each other in the eye when they agree to cooperate. It is not without reason that people fly around the world to see each other during negotiations instead of just calling each other. Research supports the efficacy of this behavior and shows that people do work better together when facing each other than when they call or send emails. In the study described in Chapter 3, I go a step further and investigate how this positive effect is influenced by what people know about each other. Past experiences make it easier to predict what a person will do in the future. Likewise, it helps to look at a person in the eyes to estimate whether or not the person can be trusted. I was interested in how these two sources of information are integrated into the decision to work with someone. The results show that both sources had a positive effect on the willingness and success of cooperation. Interestingly, the effects did not influence each

other. People cooperated more when they saw each other regardless of how much they knew about the other person and whether they could find out whether their willingness to cooperate was reciprocated or not. The "boost" in cooperation after seeing each other worked even when they were told that the other person had been selfish before. In other words, the study shows that the positive effect of looking at each other on cooperation is quite robust.

The next question is then of course: What exactly is it in the face that makes people work better together? People have developed a so-called signaling system where nonverbal signals such as body language and facial expressions communicate to the people around us what we think and feel. In addition to the visible signals, there are also many changes within a person that influence how we perceive others and what decisions we make during an interaction with that person. When a man looks at the woman he is in love with, not only does a big smile appear on his face, but his hands start to sweat and his heart starts to beat wildly. Such changes, albeit less extreme, also occur when we make decisions about whether we trust others and consequently want to work with them or not, especially if these decisions have far-reaching consequences.

The visible and invisible changes associated with a decision whether or not to work with someone have been largely investigated through computer tasks. For example, photos of fictional interaction partners are manipulated to investigate the influence of certain signals (e.g., a person who smiles or not). Another method is to look at the nonverbal (physical) reactions of participants while they look at the photos and make decisions. This controlled way of investigating how we express our feelings and intentions and perceive them in others has given us many insights. However, cooperation by definition takes place between at least two people. To understand how people work together successfully, it is therefore necessary to study actual interactions rather than one-person computer tasks. Therefore, the four empirical articles I present in the thesis are based on studies where two people interact with each other, sometimes by playing games to measure their prosocial behavior (Chapters 2 to 4) and sometimes by telling stories (Chapter 5).

Bringing two participants together gives a new perspective to look at nonverbal communication because there is an interaction between the signals from the two people. A person can respond directly to the nonverbal signals from the other person and vice versa. In fact, research shows that people mirror the signals from each other. Such mirroring, also called mimicry or synchrony, takes place at different levels such that people engaged in a social interaction show similar patterns in their behavior (for example, in facial expressions), physiological responses (for example, changes in heart rate), and neural activity. The mirroring ensures that people are able to put themselves in the shoes of another person, to feel their emotions and to adjust their behavior accordingly, for example, by showing empathy or helping.

In the study discussed in **Chapter 4**, I investigated the influence of synchronizing physiological responses on cooperative behavior. Are people who synchronize more successful in working together? The study shows the answer to this question is: yes. Dyads that showed a similar arousal level during the experiment were better at cooperation. This effect was amplified when people looked at each other, that is, when they could exchange nonverbal signals. Arousal level was measured by looking at the skin conduction level of their fingertips. The more

someone gets excited, the more the person sweats and the higher the skin conductance level. The fact that people synchronized their arousal level more when they looked at each other compared to when there was a visual cover between them shows that people can pick up subtle changes in their physiological responses through changes in their faces and adjust their own responses to them. Subsequently, even if we are not aware of them, these small changes can affect the way we interact with other people.

The question which then interested me the most was how best to express the synchronization of physiological responses between two people in numbers. The study discussed in **Chapter 5** addresses this question. Ideally, you want to have a measure of how well people synchronize with each other, taking into account the dynamics of a natural conversation. There are two aspects that play a role in this. First, there are changes in the degree of synchrony over time because there are always times when people mirror each other very well and other times when things go less smoothly. Secondly, delays in reactions between two people arise because people do not perfectly synchronize the same reactions at the exact same time. Windowed Cross-Correlation is a statistical analysis that takes both aspects into account. The advantage is that the analysis can be tailored to the signal you are interested in by adjusting certain parameters. For example, changes in skin conductance level are quite slow, so how well people synchronize at this level also changes slowly. On the other hand, if you are interested in mirrored facial expressions, the changes will occur faster because the facial expressions themselves change faster. These differences in the speed of signals can be included in the analysis. However, this advantage is at the same time a drawback because there have been no guidelines on how to choose the parameters. As a result, the parameters diverge considerably between studies while this can have a major impact on the estimated degree of synchronization. In Chapter 5, I present a study setting up these guidelines for four different physiological measurements: heartrate, skin conductance level, pupil size, and facial expressions. Using two criteria, I compare a range of options for the parameters for each measurement and see which are the most suitable. The results show that there is not one optimal parameter setting, but that multiple parameters are appropriate from a statistical point of view. By integrating these findings with theoretical considerations, I develop guidelines for choosing the right parameters.

In summary, the current dissertation shows that successful cooperation is more than the sum of the contributions of two individuals. Our behavior is influenced by how our bodies respond to each other, a process that happens automatically and unconsciously. Whether these results will hold up outside the lab is a question for further research. However, this thesis shows that methodological challenges arise when researchers leave the safe path of the controlled, somewhat artificial setting of the lab. These challenges are not insurmountable, but must be taken into account when researchers want to set up follow-up studies and compare findings where different tasks were used. This dissertation also shows that the appropriate statistical analysis and guidelines for the correct application of analyses can help to make results from different studies more comparable with each other. This brings us a step closer to better understanding complex processes such as nonverbal communication, and its influence on behavior such as cooperation.