# Connecting minds and sharing emotions through human mimicry

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# Chapter 1

## General introduction

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# General introduction

Facial movements and bodily sensations play a fundamental role in social interactions, as demonstrated by our spontaneous inclination to synchronize emotional expressions with those of another person. The tendency to automatically mimic and synchronize with others has been suggested to result in emotional contagion – the ability to 'catch' another person's emotion (Cacioppo et al., 2000). Contemporary theories propose that emotional contagion may give rise to advanced human social capacities such as empathy, trust, and the ability to bond with each other (Preston and de Waal, 2002). Decades of neuropsychological research have been devoted to understanding the way human emotions are constructed in the brain, how they are influenced by internal and external factors, and the role they play in social interactions. However, while most research has been dedicated to motor mimicry (e.g., the mirroring of facial expressions and body postures), very little is known about the function of autonomic mimicry that is unconscious and difficult to regulate. To illustrate, imagine the following scenario:

*A friend of yours has an important presentation. She is standing on a big stage, introducing the topic, while you are sitting in the first row. Suddenly, you notice the blush on her cheeks, the sweat on her forehead, the dilation of her pupils, and the tremble in her voice. As you take note of these details, you recognize changes in your own body: your heart rate is rising, your hands are perspiring, and despite your best efforts you are beginning to feel extremely anxious.*

This scene describes emotional contagion - the most primal form of empathy (Preston and de Waal, 2002). Compared to our closest relative, the chimpanzee and bonobo, homo sapiens evolved expressive faces with smooth skin, large eyes and red lips that make our internal states more transparent (Tomasello et al., 2005). Partly because of these exaggerated features, humans are hardwired to share and communicate emotional states freely and without effort. People are able to adapt to others' emotions to the point where we can feel other peoples' pain, feel sadness in response to others' tears, and predict someone's surprise before the surprising event even happens. If you notice that a friend is in a stressful situation, it's adaptive to be on guard as well. However, there is a mismatch between how this contagion system evolved and how it is often activated in contemporary human life. From an evolutionary perspective, experiencing a stress response by witnessing a friend struggle through a presentation does not appear to have any adaptive value. In fact, if you feel highly stressed this reduces your ability to put your friend at ease and provide needed support, which could increase the stress of your friend (Bloom, 2016). Therefore, one may argue that such emotional transparency could put humans in a vulnerable position by increasing the risk of predation and exploitation. On the other hand, it has been proposed that emotional contagion may provide a much greater benefit: because humans' bodies mirror what we perceive, we can feel what others feel. This makes us care for each other deeply, and cooperate on a greater scale than any other species (Preston and de Waal, 2002).

In this thesis, I will explore the questions: what is the function of mimicry in human interactions? And furthermore, what underlies this remarkable capacity? Whereas most studies have focused on mimicry of facial expressions or body postures, I take a broader perspective and review evidence showing that people mimic each other on many more levels than previously thought. Special attention is given to autonomic mimicry (synchrony in heart rate, skin conductance, and pupil diameter), which is an underexplored area of research (for a review, see Kret, 2015; Palumbo et al., 2016). Overall, the aim of this thesis is two-fold: the **1st aim** is to explore different types of mimicry with respect to pro-social behavior. The **2nd aim** is to understand the underlying mechanisms of this mimicry. To reach these goals and sustain the ecological validity of our findings, we used a variety of tools measuring eye-tracking, skin conductance, heart-rate, and also employed brain stimulation, optical illusions, and neuroimaging. We furthermore conducted research both inside and outside of controlled laboratory settings.

# Chapter Overview

This dissertation is based on one literature review and four empirical research articles. The whole thesis can be divided into three overarching topics: The first section (Chapters 2-3) presents a literature review summarizing evidence suggesting different types of mimicry that emerge early after birth. In Chapter 3, this review is extended to examine the neurocognitive mechanism of emotional contagion, introducing two distinct neurological pathways: the autonomic pathway and the motor pathway that give rise to two distinct types of mimicry. The second section (Chapters 4-5) provides empirical evidence for the theory that autonomic is liked to pro-social behavior (trust and attraction). Lastly, the third section (Chapter 6-7) shifts away from the previous correlational approach with experimental manipulations.

**Chapter 2** provides foundations for the view that mimicry is a primitive, automatic and implicit form of empathy that plays a crucial role in the development of human social abilities. A distinction is made between two separate branches of mimicry - autonomic (physiological) and motor (facial) mimicry. Evidence is summarized implying that autonomic and motor mimicry are related to various pro-social abilities such as bonding, trust, and empathy.

**Chapter 3** looks deeper into the underlying mechanisms of autonomic (physiological) and facial (motor) mimicry. The Neurocognitive Model of Emotional Contagion (NMEC, Procházková & Kret, 2017) proposes two neurological mechanisms by which mimicry shapes social behavior: autonomic mimicry is linked to a subcortical pathway involved in nonconscious affective processing. Motor mimicry, on the other hand, is reliant on the mirror neuron system (MNS) in the cortex that is involved in conscious imitation. Thus, whereas chapter 2 and 3 introduce different types of mimicry along with possible neurological mechanisms, Chapters 4 - 7 scrutinize this neurological model with the use of a variety of tools including eye-tracking, physiological measures, brain stimulation, optical illusions and fMRI.

**Chapter 4** describes an fMRI experiment in which we looked into the underlying mechanisms of pupil mimicry and it's link to trust formation. Pupil mimicry is a particularly useful phenomenon to study because in contrast to most other types of autonomic mimicry (e.g., skin conductance, heart rate synchrony), pupils can be visible to others and therefore can be used as a visual stimulus to induce an autonomic response. In this experiment, participants played a series of one-person trust games inside of the MRI scanner. During each trial, the pupils of virtual partners dilated, constricted, or remained static, while subjects decided how much money they wanted to invest in the partner whose eyes they perceived. This set-up allowed us to track participants' brain activity and social behavior on a trial-by-trial basis. We were particularly interested in neural areas that became active during pupil mimicry and how these pupil mimicry-related regions modulated participants' trust decisions.

The highly controlled experimental setting presented in Chapter 4 has an intrinsic advantage in reducing confounding variables. Yet, studies in social neuroscience frequently face criticism for overly artificial tasks and the presentation of un-naturalistic stimuli. In real-life social interactions, there is not only one type of affective cue but a whole variety of signals that are being dynamically exchanged between partners. Thus, to improve the ecological validity of our findings, in **Chapter 5**, we measure the physiological dynamics between couples during real-life dating interactions outside the laboratory. A first date provides an excellent scenario in which to test if physiological synchrony promotes pro-social behavior. During dating interactions people are likely to exchange a broad variety of facial expressions and gestures and to experience concomitant changes in attraction to their dating partner. Participants wore eye-tracking glasses with embedded cameras as well as devices to measure physiological signals. Here the main focus was on signals that are difficult to perceive such as heart rate (HR) and skin conductance levels (SCL). We hypothesized that mutual synchrony in HR and SCL would boost attraction between newly met partners, an effect consistent with the observation that pupil mimicry promotes trust between strangers.

In **Chapter 6,** we test the NMEC proposal that autonomic signals (pupil sizes) are processed subconsciously. In support of this theory, an increasing number of studies have shown that affective displays can be perceived outside of perceivers' awareness (Skuse, 2003; Tamietto et al., 2009; Tamietto & De Gelder, 2010). We, therefore, returned back to the laboratory and took a more controlled approach. Participants played trust games as their pupil size and facial expressions were measured. They would either see their partner's face with a neutral, happy, or fearful expression, or partner's eye region in which the pupils were large, medium or small in size. Crucially, in half of the trials, we used continuous flash suppression (CFS; Tsuchiya & Koch, 2005) to render the stimuli they saw invisible. The main interest was to test whether facial expressions and pupils of partners were mimicked and influenced trust decisions even during the non-conscious (suppressed) condition. If true, this result would support the theory that autonomic signals can be processed without visual awareness of the perceiver.

**Chapter 7** presents a study where we manipulate autonomic mimicry with brain stimulation. In this experiment, we used transcutaneous vagus nerve stimulation (tVNS); a method that has been proposed to increase norepinephrine concentrations in the brain and which we expected would induce pupil dilation. Participants' pupil sizes and investments were measured as subjects played trust games with partners whose pupils changed in size. We hypothesize that tVNS would modulate pupil mimicry and pupil-contingent trust. If true, this finding would provide causal evidence for the role of the noradrenaline system in pupil mimicry-promoted trust development.

Finally, **Chapter 8** closes the thesis with a general discussion, where I highlight and integrate the key findings from the different chapters. I also pose new questions that this dissertation yields.