# Using body signals to study the norms that drive creative collaboration

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**Abstract** Using body signals to understand the norms that drive creative collaboration is research in progress focusing on norms that guide creative collaboration. The authors bring together concepts from (a) complex systems theory and (b) enactive ecological approach to cognition, to account for the emergent and dynamic nature of norms. We also look at basic results from our preliminary experiment, a study of norms at a team and individual level as well as its "circular causality". Our study takes the particular perspective of correlations between changes in the synchronization of body-signals and the normative status of the collaborative interaction.

**Introduction** Humans are 'normative animals'. Even more, extensive literature shows how norms have played a key role in the evolution and maintenance of human cooperation, collaboration, social institutions, and culture (Schmidt and Rakoczy 2019; Boyd and Richerson 2009; Tomasello and Vaish 2013). Human normativity is the foundation of human's evolutionary game-changer: large scale cooperation and collaboration among genetically unrelated strangers. This capacity for normativity lies at the core of "uniquely human forms of understanding and regulating socio-cultural group life" (Schmidt and Rakoczy 2019). Teams and creative collaboration are the engines of innovation. This study seeks to expand our understanding of team dynamics and collaboration by understanding its norms. Social norms are "standards of behavior that are based on widely shared beliefs how individual group members ought to behave in a given situation" (Fehr and Fischbacher 2004). Norms tell us "what to do" and "how to do" in different situations - regulate our actions when engaging with others in a team.

However, the study of norms faces two challenges: (1) they are largely invisible, as they are implicit in the interaction of the participants and (2) norm-based environments are complex dynamic systems, they are not "simply being imposed on agents a priori" (Hadfield-Menell et al. 2018).

**Team Dynamics and Norms: a Complex Systems Theory approach.**

This study understands creativity as a process that emerges through collaboration. The creative process has its own existence in the form of a self-organizing and emergent system. The background theory is systems theory from biology, sociology, and creativity (Maturana and Varela 1980; Iba 2010; Luhmann 1982).

*Creative collaboration: Norms as media for coupling of systems.*
Teams are self-organizing social systems that emerge from the effective coupling of psychic systems (team members). As a system of systems, teams have a precarious existence. This existence depends on the strength of the structural coupling of systems that is uncertain; it may happen or not. The coupling occurs through perception-action between *the team members and its environment.* To provide certainty to this coupling, *media*– an evolutionary artifact– needs to come in place to guide the perception and action of team members (Iba 2010). To our account, *norms are media that facilitates the structural coupling between psychic systems –team members– that affords collaboration to emerge*. In other words, norms are cultural outcomes that increase our chances to survive.

**Norms in the environment: an enactive-ecological approach**

Our perception and our actions are guided by norms present in our environment (Rietveld 2008). Norms are perceived by the agents through affordances (Gibson 1979). Affordances, in a broad sense, offer the agent possibilities for action. In the case of norms, not only *what* actions but also *how* to act. Those affordances emerge from the interaction between the agent and the *socio-material environment*. It means the social interaction and cultural setting as well as the physical context in which collaboration emerges (Clancey 1997). An enactive-ecological account of norms implies that norms are dynamic, emerging in the socio-material landscape. In this sense, "norms must also be understood as an embodied and situated practical sensitivity to the unfolding dynamics of the here-and-now contextual particularities of practices" (Lo Presti 2016). Therefore, affordances are possibilities for skilled action depending on the competencies that the group of agents has. The different norms that emerge are defined by the practice and experiences of the team members and the setting in which they are situated –the rich socio-material landscape of affordances (van Dijk and Rietveld 2016).

**Creative Collaboration and Norms: individual and team level**

The understanding of teams as complex systems implies a multidirectional causality of its dynamics. As in situated cognition, "one of the fundamental concepts is that cognitive processes are causally both social and neural. A person is obviously part

of society, but causal effects in learning processes may be understood as bidirectional" (Roschelle and Clancey 1992). The same applies to teams and individuals. The team behavior and its normative status affect the physiological responses of the team member. Likewise, the team member's physiological processes affect team behavior and team norms.
To capture this bidirectional causality – the individual and the team- this study leverages advanced approaches using digital technology for data collection and analysis. In this research in progress, we collected and analyze physiological data using wearable devices and perceived team cohesion via self-assessment.

## Experiment design

In our preliminary study, participants engaged in a creative collaboration task provide a proof of concept for using body signals to understand the norms that drive creative collaboration.

*Participants*
For this preliminary experiment 10 participant –6 female– were recruited from a group of graduate students from a digital engineering institute in Germany. Regarding their profession, all of them are researchers in the field of computer science with a highly homogenous cultural background –northern European– and none of them was a native English speaker. The age of the participants was between 21 and 28 years and had no previous experience working together. The participation was voluntary– not subject to any payment. The participants were paired based on their time availability, which resulted in four gender-diverse dyads and one dyad of females. All participants signed the corresponding informed consent form.

*Task description*
The experiment was to collaboratively work with a wooden puzzle. The experiment was divided into three consecutive tasks, each one of them with the same 3-D wooden puzzle of a Dinosaur but with a different set of instructions. The total length of the experiment was 45 minutes, including 5 minutes of baseline before the task 1,2 &3. Every task lasted for 5 minutes and was followed by a 3 minutes break to fill a survey on Perceived Team Cohesion [PTC] (see table 2).

| **Task 1** – Situated normative status (5 minutes) | **Task 2** – Discordant normative status (5 minutes) | **Task 3** – Prescriptive normative status (5 minutes) |
|---|---|---|
| Participants were told to collaborate creatively and provided with a 3-D wooden puzzle and its cover (see fig. 1). | Participants received slightly **different** written instructions to assemble the puzzle, showed for 10 seconds. | A visual guide on how to assemble the puzzle was provided (see fig 1). |

**Table . 1**. Description of the three tasks of the experiment. Between every task the participants had 3 minutes to fill a perceived team cohesion survey.


**Fig. 1. Dinosaur Set 1, cover sheet (left side) that served as visual instructions for the task and one of the pages of the assembly guide (right side) provided to the participants at the beginning of task 3.**

The following task instructions were given to the participants: For task 1, the participants the puzzle and it's cover, without any other instruction. For task 2, two different written instructions to assemble the puzzle through creative collaboration. For task 3, no instructions but an assembly guide of the puzzle (see fig.1).

## Data collection

The data collected during the experiment consisted of Perceived Team Cohesion, electrodermal activity [EDA] and heart rate [HR]. The perceived team cohesion survey has 10 questions and uses a Likert scale adapted from the paper "Physiological evidence of interpersonal dynamics in a cooperative production task" (Mønster et al. 2016). For the collection of EDA and HR data from the participants, we used the Empatica E4 wristband (Garbarino et al 2014). The data collection was done using a stationary setup; no audiovisual staff was present during the recording.

| |
|---|
| Based on what happened during the task right before… |
| 1) I liked the other participant. |
| 2) I would like to interact with the other participant again. |
| 3) The other participant is a person I could see having as a friend |
| 4) The other participant was warm. |
| 5) The interaction with the other participant went smoothly. |
| 6) I feel held back by the other participant. |
| 7) I do not fit in well working with this person. |
| 8) I felt uneasy with the other participant. |
| 9) How much did you want your group to perform well? |
| 10) We did not have to rely on one another to complete the task. |

**Table. 2.** Survey questions on perceived team cohesion was collected from every participant individually after each task using a Likert scale.

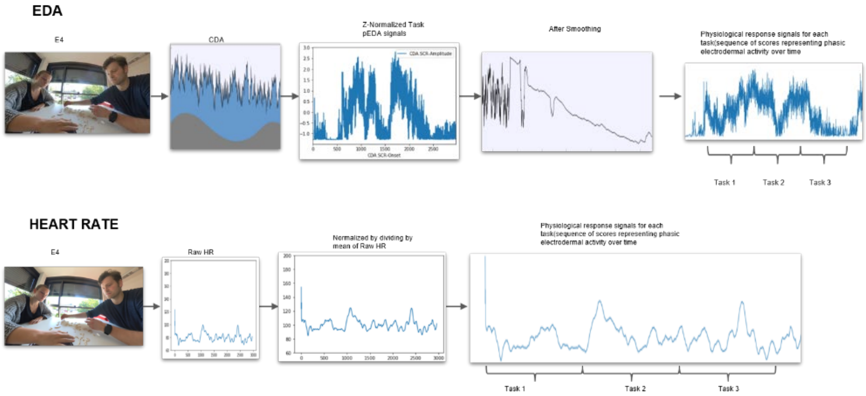


**Fig. 2 Data processing of electrodermal activity [EDA] and heart rate [HR] included phasic extraction using continuous decomposition analysis [CDA] and data normalization. After that, the data corresponding to task 1,2 & 3 was manually extracted and synchronized.**

We processed the raw data for each participant and visualized it using Ledalab. For HR, the process is very straightforward. For EDA, the raw data consists of phasic and tonic EDA. To study the synchronization of two signals we need to extract the phasic– arousals. To extract it we used Continuous Decomposition Analysis. Because of individual dependency of EDA and to avoid noise, we smoothed the data and normalized it using a z-score normalization on the signal.
In the phasic EDA sheet, we got two columns, one is the timestamp and other is the amplitude of the signal. We cut the data manually in the interval of desired time in seconds by the column of the timestamp. The data for two participants for each task were plotted in one graph to analyze the synchronization between both of them.

## Data Analysis

*Synchrony of Physiological Signals.*
We used Dynamic Time Warping [DTW] (Chikersal et al. 2017) to analyze the synchrony of EDA and HR signals between two partners in a dyad. DTW is an algorithm for measuring the similarity between two temporal sequences that vary in time and speed. DTW provides the distance between the partners' physiological response signals for each task. We enforced a locality constraint of 5 seconds while searching for the nearest points between the signals. As the Frame rates of the EDA signals are 4 Hz in our case, the constraint window consists of 20 samples within which we searched for the similarity.
Once we had the synchrony coefficient for every dyad for task 1, 2 & 3 we looked for the correlation between the different signals and the perceived team cohesion [PTC] data from the survey using Pearson Correlation Coefficient [PCC] (Hernandez 2014). The PCC range from 1 to -1 (positive to negative/inverse correlation).

| | EDA DTW | HR DTW | PTC |
|---|---|---|---|
| EDA DTW | 1 | | |
| HR DTW | -0.5050653459 | 1 | |
| PTC | 0.1388752957 | 0.4336875968 | 1 |

**Table. 3.** The correlation coefficient between electrodermal activity synchrony [EDA DTW], heart rate synchrony [HR DTW] & perceived team cohesion [PTC] using the Pearson Correlation Coefficient.

From the analysis of the correlation coefficient between the three data sets, we can observe a dissociation– negative correlation– between HR and EDA synchrony. This counterintuitive result has also been found in other studies (Chikersal et al. 2017). The positive coefficient between EDA synchrony and perceived team cohesion is not strong enough to draw conclusions on their correlation. A larger group and a different experimental design could strength the correlation. An interesting finding is a positive correlation between HR synchrony and PTC. This correlation can be explained because of the strong disruptive normative status introduced during task 2, which correlated to negative PTC in task 2 (Mikic et al. 2000, Chikersal et al.2017).

## Conclusions

As a preliminary study investigating the quantitative correlations between different levels of normative agreement, levels of perceived team performance and physiological synchronization, the experiment provides a feasibility proof for further research with a large group of participants and more means of measure synchronization to understand social norms. Quantifying social norms opens up new opportunities. Norms are at the core of human collaboration. Therefore, advancing our understanding of social norms is the key to any other forms of collaboration.

## Future research

Social norms are invisible and dynamics but people can navigate them quite successfully thanks to pragmatic social cues found in the environment. This research in progress focused on synchronization of body signals as a mean for the understanding of social norms. Despite the findings of positive correlations between perceived team cohesion and HR, the social norms puzzle is incomplete. Future research will focus on other social cognitive vehicles such as body posture, facial expressions, gestures, eye movement and communicative actions to gain a better understanding of social norm in a similar fashion people do. Adding these different pieces together can give us a map of the coupling structures of social norms.

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