



## Building trust: Heart rate synchrony and arousal during joint action increased by public goods game



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### HIGHLIGHTS

- Public Goods Game introduces trust related conditions during a joint action task.
- Heart rate arousal is increased in the trust related condition.
- Heart rate synchronization is increased in the trust related condition.
- Heart rate synchrony is predictive of the participants' expectations.
- Physiological coordination maybe a marker of a trust building process.

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### ABSTRACT

The physiological processes underlying trust are subject of intense interest in the behavioral sciences. However, very little is known about how trust modulates the affective link between individuals. We show here that trust has an effect on heart rate arousal and synchrony, a result consistent with research on joint action and experimental economics. We engaged participants in a series of joint action tasks which, for one group of participants, was interleaved with a PGG, and measured their heart synchrony and arousal. We found that the introduction of the economic game shifted participants' attention to the dynamics of the interaction. This was followed by increased arousal and synchrony of heart rate profiles. Also, the degree of heart rate synchrony was predictive of participants' expectations regarding their partners in the economic game. We conclude that the above changes in physiology and behavior are shaped by the valuation of other people's social behavior, and ultimately indicate trust building process.

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### 1. Introduction

The ability to participate in cooperative tasks necessarily depends upon trust, that is, commitment to the other participants for the accomplishment of future collective goals [6]. Expressing and reciprocating trust is an important signaling mechanism that influences cooperative behavior among individuals, groups, and organizations [20,22,25,33,40,41]. For example, when two or more individuals decide to partake in a joint action that involves risk, one participant must trust the other with the expectation of reciprocity or there can be no cooperation [12,43].

Numerous studies have found that positive interactions lead to higher trustworthiness and cooperation [15,46]. One of the primary

means of investigating trust is through the use of economic games [3,7,8,21,34]. As a method, economic games are usually thought of as measurement instruments that capture trust. One of the most well-known economic games measuring trust is the Public Goods Game (PGG). Briefly, participants are asked to contribute to a common investment which is subsequently proportionally increased and split equally between participants. In this game the total outcome is maximized if each participant contributes maximally but individual outcome maximizes when participants do not contribute. Thus, the PGG is both a model of trust and a model for trust ([23], 87–125).

In our study, it is expected that the use of the PGG would prime participants to focus on their relationship to one another (i.e. the quality of their interaction) and display trust or positive affect [60]. In this study, we wanted to explore whether there would be physiological markers in the individual or in the couple, during an online trust building process, as exemplified by the PGG.

We had 37 pairs of participants' construct model cars using LEGO building bricks in 4 consecutive 10-minute sessions [56,42], while

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participants' heart rates were measured during the interaction to provide continuous measures of synchrony and arousal. After each building session, participants completed brief questionnaires in which they reported their experiences of the interactions with their partner regarding cooperation, experience of fun, and control over the building task. Additionally, we collected new data from another 20 pairs of participants using the same experimental setup, with the modification that after each building exercise the participants played a PGG. In this condition, which we entitled the Trust Condition (TC), participants were asked to play the PGG between each of the building sessions, while the previously collected data set was treated as the Control Condition (CC), in which no economic game was employed (Fig. 1).

We tested the effect of inducing trust on two different levels: On subjective experience, and on (continuous measures of) physiological response and behavior. We predicted that participants' heart rate profiles would be more synchronized during the TC, demonstrating an autonomic response to high levels of affective coupling between the participants [18,26,35,36]. In addition to heart rate synchronization, we predicted that increased heart rates would indicate an overall increase of arousal during the TC, as a result of positive excitement and increased social interaction awareness [59].

## 2. Methods

### 2.1. Participants

The original study [56] included a total of 74 participants (average age: 23.5 yrs.  $SD = 3.5$  yrs.). The newly collected data set consisted of 40 participants (average age: 23.3 yrs.  $SD = 2.6$  yrs.). All were students from Aarhus University. Participants were randomly assigned to pairs. Using standardized forms in the subjects' native language, the pairs were given instructions regarding the building sessions. The experiment lasted 75 min. Our protocol was reviewed and approved by the Danish National Ethics Committee. All participants signed an informed consent form.

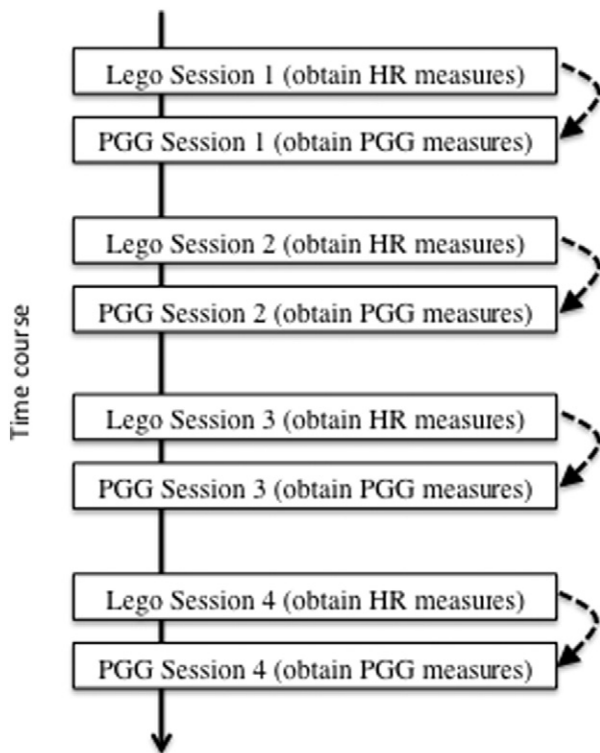


Fig. 1. Experimental procedure: A Public Goods Game was played after each building session, while heart rate measures were collected during the building sessions.

### 2.2. Public goods game

In the PGG [37], participants determine how much money (given to them by the experimenters) they should contribute to a common pool. The sum of the players' contributions to the common pool is then multiplied by a factor ( $>1$  and less than the number of the participants) and split evenly between them. Each participant also keeps the amount of money they did not contribute to the common pool. Given this setup, the total payoff is optimized for the group when players contribute all their funds. By definition, each participant consumes an equal share of the common pool, even if one of them contributed nothing to it. The standard Nash Equilibrium in a one-shot experiment is zero contribution, although it would be collectively rational to contribute everything.

### 2.3. Procedure

Participants were instructed to make optimally performing and esthetically pleasing cars. Participants were involved in four building sessions.<sup>2</sup> As aspects of coordination might be observed on the level of autonomic synchronization [19,54], participants' heart rates were recorded during all sessions with a Polar Team2 heart rate monitor around the chest. The heart rate monitors recorded the subjects' heartbeats as beats-per-minute in 1-second intervals.<sup>3</sup> For each 10-minute building session, participants received the same set of LEGO bricks as well as specialized instructions for the design and construction of their model car. Immediately upon completing each session, participants rated the building task according to their perceived cooperation, experience of fun, and control over the building of the car model's design. In the TC, in addition to the questionnaire, participants received 100 DKK (~13.5 €, Average amount given per person: 460 DKK,  $SD = 98$  DKK) from the experimenter, a paper-sheet with instructions on how to play the PGG, and a decision-sheet, where they could indicate how much from the given money they wanted to contribute and how much their expectation about the other participant's investment was. However, participants did not get feedback on how much money they would earn per game – participants were informed about their compensation only after the study was over. In the TC, participants were informed that they would play a PGG every after building session. A trial version of the PGG was implemented before the first building session. In the CC condition, participants received 450 DKK (~60.5 €).

## 3. Results

### 3.1. Data analysis

Multivariate Recurrence Quantification Analysis (MVRQA) was used to assess the degree of synchrony at the level of heart rate profiles during the building sessions. MVRQA is a time series analysis technique that measures the relationship between three or more time series and can be used to quantify their degree of synchrony [52], and recurrence-based analyses are prominent for the analysis of temporal coordination and has been used in a variety of studies [36,47,50]. To conduct recurrence analysis, the time series are projected into a phase space by the method of time-delayed embedding [51]. The time series are plotted against

<sup>2</sup> In order to keep the same procedure as in the original study [56] we employed three modes of interaction: The Egalitarian Condition, where participants received no instructions regarding except building an optimally performing and esthetically pleasing car. The Hierarchical Condition, where one participant had to make all design decisions while the other could only assist. This condition was enacted twice in back-to-back sessions, so that each participant played the role of designer or assistant once. The Turn Taking Condition, where participants were asked to take turns in constructing the car. The order of these modes of interaction was randomized for each pair of participants. The above manipulation is helpful in assessing that the physiological findings are not a result of the modes of interaction but of the economic game priming.

<sup>3</sup> In order to keep the same procedure as in the original study [56] each participant also wore an ActiGraph GT3X+ accelerometer on each wrist. The degree of hand movement synchrony did not differ as a function of playing the PGG ( $t(210) = -0.47, p = .677$ ).

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