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# How does emphatic emotion emerge via human-robot rhythmic interaction?

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**Abstract**

Sharing a same rhythm among different agents matures close empathic relationship. However it is still unclear how rhythmic information is transferred to emphatic emotion in our brain. In this paper, we propose human-robot drumming interaction system to investigate how rhythmic physical interaction brings emphatic emotion. In this paper, we introduce the detail of our proposed system.

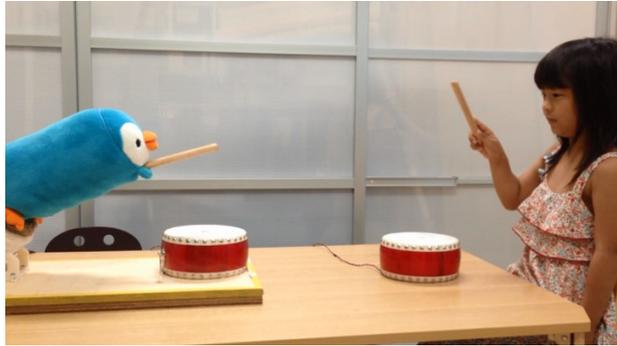
**ACM Classification Keywords**

J.4 Social and Behavioral Sciences: Psychology

**Introduction**

Empathy is a capacity for experiencing and inferring other's internal feeling and it is one of core components for animal social cognition [?]. Over the past few decades, a considerable number of studies have been made on psychological and neural mechanisms of empathy. One of interesting topics about empathy is how empathic relationship (e.g. bonding) occur via a physical non-emotional interpersonal interaction. For example, bidirectional mother-infant body imitation matures the mother-infant bonding [?]. Further even in adults, implicit mimicry brings empathic relationship between two individuals (chameleon effect) [?]. Although there are many psychological and neural experimental findings suggesting the strong link between physical interaction

and empathy, it is still unclear what kinds of information in physical interaction are transformed to empathic emotion.



**Figure 1:** Our proposed human-robot drumming interaction system named "AOKICHI"

One of possible hypotheses is that the arousal of empathic emotion strongly links to rhythmic synchronization among different agents. If audiences are emotionally excited in a concert, their body movements tightly synchronize with the music rhythm. The link between rhythm and emotion is investigated in some previous literatures [?]. For example, a child tended to show helping behaviors for other person when the child and the person shared a common musical rhythm [?]. However it is still unclear how rhythmic information connects to empathic emotion in our brain, because there are few suitable experimental platforms connecting rhythm information to subject's empathic response. In an interpersonal interaction, it is quite difficult to control the degree of rhythmic synchronization between two individuals. Hence the experimental platform that can strictly control the degree of the synchronization is required. .



**Figure 2:** An example scene of the robot suffering

We have conducted several studies using robots as the method for social neuroscience research [?] [?]. Robots can be recognized as a social partner by us. Meanwhile robot's appearance and behavior are absolutely controllable and it is useful for constructing well-controlled experimental tasks for social interaction.

In this paper, we propose a human-robot drumming interaction system to elucidate how rhythmic physical interaction brings empathic emotion (Figure1). In this system, we can strictly control the degree of human-robot rhythmic synchronization in a joint drumming task by programing the robot's drumming behavior. This system enables to investigate how the degree of rhythmic synchronization with the robot modulates empathic response when subjects watch the movie of the robot suffering (Figure2).

### The detail of our proposed system

In our system, a drumming robot named "AOKICHI" hits a taiko (Japanese drum). The robot consists of 1 degree-of-freedom (maxon DC motor RE 35, 90[W]). The position of the motor is controlled by an Arduino Uno board and a motor driver (TITECH PC-0120-2). The taiko is equipped with a piezo film sensor. The Arduino Uno board detects hitting times of subject and the robot and sends the data to PC. The overview and the system configuration of AOKICHI system are shown in Figure 3.

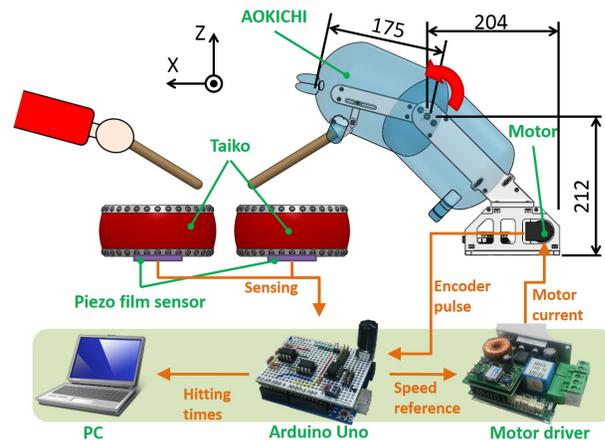


Figure 3: The overview of the system

### On going project and discussion

We are now conducting several experiments in both adults and children with this system. As a preliminary finding in adults, we found that a subject who was aware of mutual rhythm coordination (not one-way coordination) with the robot tended to show empathic response to the robot

suffering by questionnaires rating (Figure 4). This result suggests that ambiguous initiative in rhythmic interaction might bring the empathic emotion. In a child experiment, we are now investigating how the visual appearance of the robot influence child drumming behavior. Our hypothesis is that the appearance leading empathic emotion (e.g. very pretty animal-like stuff) improves the rhythm synchronization between child and robot.

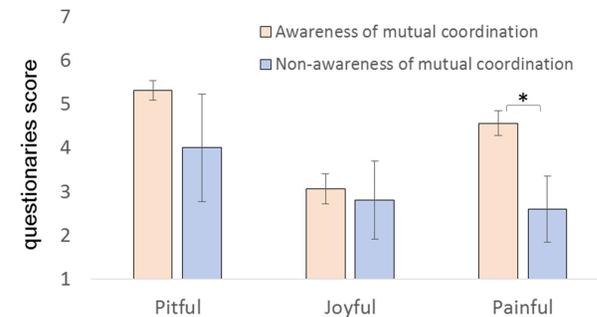


Figure 4: Preliminary questionnaire result

We believe that rhythmic information and empathic emotion tightly interact in our brain and our proposed system is very useful for elucidating the link between rhythm information and empathic emotion.

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