Four-way mirror game: developing methods to study group coordination

Tommi Himberg
Department of Neuroscience and
Biomedical Engineering
Aalto University
Espoo, Finland
tommi.himberg@aalto.fi

Klaus Förger
ICI project, Labex ARTS H2H,
Université Paris 8
Paris, France
klaus.forger@iki.fi

Asaf Bachrach
ICI project, Labex ARTS H2H,
Université Paris 8
and
UMR 7023 CNRS
Paris, France
asaf.bachrach@cnrs.fr

ABSTRACT

Mirror game is an improvisation exercise for two people, where one person moves and the other acts as their mirror. We extended this game to four people, and are investigating it as a) a method for studying group dynamics in movement coordination, and b) a measure of intersubjectivity. We used optical motion capture to record four participants mirror each others' hand movements. The overall average speed of the participants ($\bar{v}$) body parts was calculated and correlated to investigate overall movement coordination. Finger accelerations were cross-correlated for all pairwise combinations of participants, to assess the dynamics of following and leading, and mutual adaptation and influence in the group. In the pilot, we compared two games, played before and after another group improvisation exercise. The latter game produced more group synchrony, and facilitated the introduction of larger movements. The four-person game gives rise to "conflicts" where a performer must quickly decide which other player to match, leading to a mismatch with the other two. The game can be used to investigate the affective and social effects of these decisions, and the factors leading to these choices.

KEYWORDS

group dynamics, interaction, mirror game, motion capture

1 INTRODUCTION

Mirror game is an improvisation exercise for two people, where one person moves and the other acts as their mirror. In the game, the roles of leader and follower can be switched, and eventually the roles can be abolished, and the pair shares leadership, both mutually mirroring each other. The mirror game has been adapted to scientific research, to study intersubjectivity and social coordination dynamics, central topics in social cognition & neuroscience as well as human-computer interaction [1, 2]. In previous experiments, the game has been simplified to a 1D version with buttons on sliders [5], and a 2D version where participants move their hands as if drawing in the air[3]. In these studies, the condition of joint leadership has been found to somewhat surprisingly produce movements that are better synchronised and smoother than those in the leader-follower conditions, even though in the latter the roles of participants are better defined. To be able to study a richer set of social dynamics, We extended this game to four people, and are investigating it as a) a method for studying group dynamics in movement coordination, and b) a measure of intersubjective attunement. Unlike in
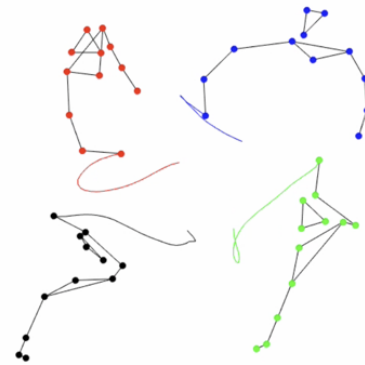

Figure 1: Game setup and placement of reflective markers.

two-person games, in the four-person formation (see Methods and Figure 1) the directions of mirroring & matching movements are not well-defined. This is intentional, as participants need to decide, on the fly, who to follow and how, which hopefully allows us eventually to gauge implicit biases and social preferences, as differences in interaction patterns between two rounds of the game. In between rounds, interventions aimed for influencing social bonding (dance, music, or other joint action) can be carried out (in different dyads, for example), and their effects on the larger group evaluated. In this paper, we describe a proof-of-context pilot and analysis, where we compare two games separated by a four-way joint improvisation.

2 METHODS

We used a 20-camera optical motion capture system. For the capture, each participant had 12 reflective markers attached to their upper limb joints, chest, head, and index fingers. In the pilot stage, we had four participants (2 female, 2 male), all experienced in dance and improvisation. They played two games, and in between, engaged in another type of group improvisation that boosted four-way co-ordination. During the games, participants stood in a circle, with their right arm and index finger extended towards the centre (see Figure 1). Participants were instructed to mirror each others' hand movements, without an assigned leader.

For this initial analysis, we calculated the average speed of all the markers (overall average speed $\bar{v}$) for each player. The $\bar{v}'s$ of the players were then correlated with those of the other players, to have a simple measure of the overall movement coordination in
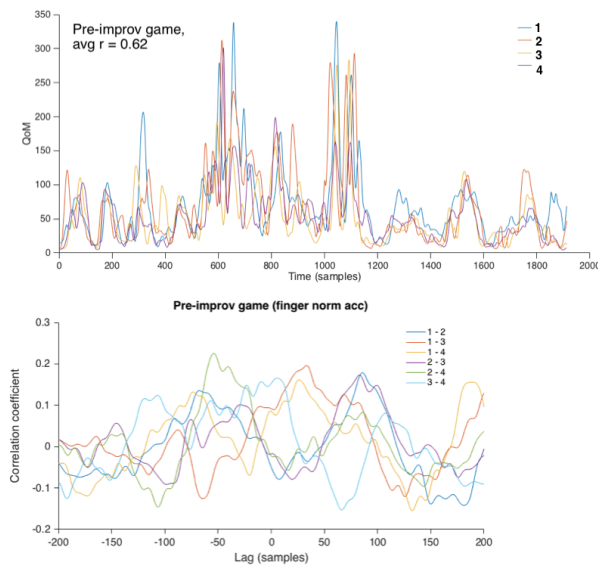
Figure 2: Top: Overall average speed for each player. Bottom: cross-correlation of finger norm accelerations for each dyad.

Figure 3: Top: Overall average speed for each player. Bottom: cross-correlation of finger norm accelerations for each dyad.

the game. A more detailed analysis was conducted on the finger tip movements. The Euclidean norm of the acceleration of the extended fingers was calculated, to obtain their accelerations along the trajectories. This allowed easy comparisons between players, as only the magnitude of the accelerations was preserved, and not the direction. Cross-correlations of the accelerations were calculated for each pairwise combination of participants, with a maximum lag of 200 samples (2 seconds).

3 RESULTS

Comparing the $\bar{v}'s$ of the two games, the first game produced a less correlated performance (Figure 2, top), and the cross-correlations indicate that overall, no pairs emerge as very well coordinated (Figure 2, bottom). The second game has higher $\bar{v}'s$ peaks than the first (Figure 3, top), indicating that participants were conducting larger sudden movements.

In the second game, we also see a more coherent cross-correlation structure (Figure 3, bottom). Participants are numbered in clockwise direction, so the adjacent numbered players are standing next to each other in the game. Looking at the peaks that are closest to the lag 0, we can see that they all are from dyads of adjacent players. Thus players seem to follow the players next to them more closely than players they are facing.

4 CONCLUSIONS

Our pilot study suggests that the four-person game produces phenomena that are interesting from group dynamics point of view, for example the emergence of subgroups [6]. The task gives rise to "conflicts" where a performer must quickly decide which of the three other players to match, and can lead to a mis-match with the other players, and in general, weaker four-way coordination, as in the first performance in the pilot. Prior research indicates
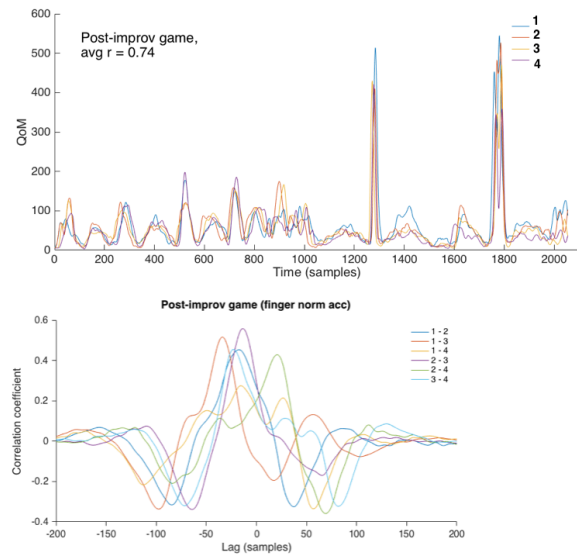
that synchronisation and coordination lead to positive affective and social outcomes [4, 7], the four-way game offers a potential to study these effects and mechanisms in more detail.

In the pilot, the latter game produced better group movement coordination, and facilitated the introduction of larger movements. This is probably due to the group improvisation in between, where participants were all holding on to a piece of paper and were "following its movement". This provided them with a potential solution to the arising conflicts: if all four aim to minimise the distance between their hands, they maintain a coordinated state, even though they are no longer, strictly speaking, mirroring movements. In the experiments to be conducted in the spring 2017, a musical group improvisation task will be used instead, to avoid such direct effects.

REFERENCES

[1] Paul Dourish. 2001. Seeking a foundation for context-aware computing. *Human–Computer Interaction* 16, 2-4 (2001), 229–241.
[2] Alex Gillespie and Flora Cornish. 2010. Intersubjectivity: Towards a dialogical analysis. *Journal for the theory of social behaviour* 40, 1 (2010), 19–46.
[3] Tommi Himberg, Maija Niinisalo, and Riitta Hari. 2015. Coordination of Fluent Hand-Movements in Dyads. Amsterdam, Netherlands.
[4] Michael J. Hove and Jane L. Risen. 2009. It's All in the Timing: Interpersonal Synchrony Increases Affiliation. *Social Cognition* 27, 6 (2009), 949–960. DOI: http://dx.doi.org/10.1521/soco.2009.27.6.949
[5] Lior Noy, Erez Dekel, and Uri Alon. 2011. The mirror game as a paradigm for studying the dynamics of two people improvising motion together. *Proceedings of the National Academy of Sciences* 108, 52 (2011), 20947–20952. DOI: http://dx.doi.org/10.1073/pnas.1108155108
[6] Henri Tajfel. 1982. Social psychology of intergroup relations. *Annual review of psychology* 33, 1 (1982), 1–39.
[7] Piercarlo Valdesolo, Jennifer Ouyang, and David DeSteno. 2010. The rhythm of joint action: Synchrony promotes cooperative ability. *Journal of Experimental Social Psychology* 46, 4 (2010), 693–695.