An EEG hyperscanning setup to investigate collaboration in games

Stefan Glasauer
Brandenburg University of Technology Cottbus-Senftenberg
Computational Neuroscience
03048 Cottbus, Germany
stefan.glasauer@b-tu.de

Margarete Jahrmann, Georg Luif
University of Applied Arts Vienna
Experimental Game Cultures
A-1010 Wien, Austria
margarete.jahrmann@uni-ak.ac.at, georg.luif@uni-ak.ac.at

Theresa Rahel Demmer, Matthew Pelowski
University of Vienna
Department of Cognition, Emotion, and Methods in Psychology
A-1010 Wien, Austria
theresa.demmer@univie.ac.at, matthew.pelowski@univie.ac.at

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INTRODUCTION

Collaboration and opposition are inherent mechanics of many games, and it often happens that a specific move is performed once by a collaborator, and another time by an opponent, and yet we have no problem of properly reacting to both, usually with entirely different moves of our own. Is that context-dependent switching of strategy already prepared by the perceptual process, that is, do we already 'see' the opponent's move differently from that of our collaborator, even though both are the same in terms of sensory events? Or is it the subsequent deliberation prior to our own move that makes the difference? Do we prepare ourselves for the moves of the opponent in a different way than for that of our teammate? Is our brain activity similar to that of our partner, when we observe what our opponent does? Here we describe a novel setup to investigate these and other questions experimentally by using the neurophysiological method of electroencephalography (EEG) to unravel possible differences and similarities in brain activation for different contexts of player moves. To this end, we developed a novel card game with simplified rules that is played as computer game for three players whose brain activity is recorded simultaneously and continuously during the game.

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THE CARD GAME

Trick-taking card games for more than two players usually involve teams of players, who collaborate with each. While some card games feature fixed teams, in others, such as in the well-known German game *Skat* or the Bavarian *Schafkopf*, teams change in every round of the game. This offers the unique opportunity to disentangle the collaborative role in a game from the actual players, because your opponent in this round may become your partner in the next one. From the perspective of ludic experimental investigation (Jahrmann 2024), this role change is an advantage, because the particular role is not linked to an individual. However, most existing trick-taking card games are confined to specific regions and cultural backgrounds and would require a considerable amount of training for newcomers. We therefore developed a new game with simplified rules inspired by other point-trick games such as *1001* or *Russian Schnapsen* (Braun 1966), but much easier to learn. This had the advantage that participants in our experiments did all start without being familiar with the exact rules but could learn them easily in a training session. Our game is played with 32 cards, three players, and each player gets only 5 cards. There are no trumps, suit is irrelevant, cards rank in descending order (A 10 K Q J 9 8 7) with points as in *1001*. If a trick cannot be decided, it is placed in a pot and the next trick decides. The goal is to collect more than 500 points over multiple rounds.

THE EXPERIMENTAL SETUP

Electroencephalography (EEG) is a method of recording brain activity by measuring the minuscule changes in voltage generated by the activity of neurons in the cortex. It is specifically well-suited to detect rapid changes caused by sensory signals or motor actions, so-called event-related potentials, and to analyze rhythmical activity that is supposed to be correlated to specific brain states such as relaxation or attention (Peylo et al. 2021). EEG has already been used in studies on gambling and gaming (for review, see Simkute et al. 2024,) and a few studies used card games for analyzing specific aspects of behavior, for example, concerning risk prediction error (Lauffs et al. 2020) or predictability of actions (Krol et al. 2020). In our setup, EEG is measured simultaneously in all three players, so-called hyperscanning, which provides the possibility to investigate similarities and differences between participants' brain activations and which is of specific interest when investigating social interactions (Zhang et al. 2017). To our knowledge, EEG hyperscanning has been used with a card game only once before (Babiloni et al. 2007). In contrast to that study, we used a computerized version of our card game, so that movement artifacts could be minimized, and all game-relevant events could be recorded simultaneously with the EEG data with a temporal resolution in the millisecond range. The computerized game was implemented using the Unity game engine (Unity Technologies, US) and displayed on three identical 60 Hz computer screens, as input device we used custom-made 5-button response pads, EEG was measured with 500 Hz sampling rate using 32-channel LiveAmp amplifiers (Brain Products GmbH, Germany) equipped with actiCap wet electrodes, and the signals from the Unity engine and the three EEG systems were synced and collected using the Lab Streaming Layer (Kothe et al. 2024), a network protocol and toolbox specifically developed for neurophysiological applications. We recorded two sessions of approximately 20 min of game play for each triple of participants.

CONCLUSION

Our preliminary results from eight triples of players show consistently good acceptance of the game with players expressing how exciting, interesting, and enjoyable the game has been. Evaluation of the recorded events allowed to successfully reconstruct the complete game play, which is a prerequisite for analyzing context-dependent brain activity. Preliminary EEG data analysis shows consistent event-related potentials for game relevant actions such as cards being played or buttons being pressed. Thus, our computerized role-change card game together with EEG hyperscanning offers unprecedented possibilities for analyzing player behavior and brain activity related to collaboration, risk taking, prediction, context-dependent responses, and other game-related issues.

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