Poster: The Effect of Team Familiarity in Collaborative Learning Tasks: An AR+EEG Exploratory Study

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Abstract
With the rapid development of technology, collaborative tasks that rely on technology can hardly be separated from our everyday life. Since the relationship between collaborators can greatly affect team behaviors and task performance, this study aims to investigate the effects of team familiarity on the decision-making process and the consequent performance of computational thinking tasks. To analyze collaborative learning strategies, apart from the conventional analyses (e.g., system logs and survey questionnaires), the electroencephalography (EEG) signal is captured to further identify participants' decision-making processes.

Author Keywords
EEG; Team Interaction; Decision-making; Collaborative Learning Strategies

Introduction
Collaborative learning, goes along with the trend of flipped classrooms, has attracted significant attention from research and teaching fields in recent years. Given the fast pace of technological development, the barrier for participating in collaborative learning tasks is getting lower gradually. Studies show collaborating with acquaintances can contribute to better outcomes than nominal groups, where participants believe their strategies are more effective when co-working with an acquaintance [4]. To explore the factors of different brain activities that causes the forementioned result, the present research focuses on investigating the influence of team familiarity on group decision-making process and its consequent task performance. The task performance (e.g., interaction time or task completion ratio), communicative behaviors, and electroencephalography (EEG) signals are used to examine participants' decision-making process.

Over the past decade, there has been a growing interest in augmented reality (AR) systems. The AR-based virtual simulations enable users to interact with a variety of applications regardless of physical restrictions [2], which benefits the efficiency of establishing a common ground between collaborators [6] as well as increases user engagement and enhances team collaboration [3]. Since AR has shown promising influences on facilitating

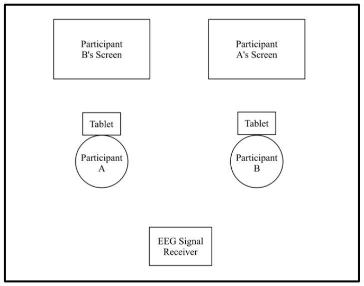

Figure 1: Experiment equipment location planning

Figure 2: Screenshot of the collaborative task (hard task)

collaborative behaviors, an AR testbed system is therefore adopted in our study to provide the team collaboration tasks. The collaborative experimental task requires a pair of users to develop team strategies to practice computational thinking skills and perform relevant activities via the AR application.

This study compares two-person teams of operators with different team structures. 16 pairs of users (i.e., 32 participants) will be recruited, where half of the participants know each other prior to this study and the other half of participants will be paired with strangers (i.e., 8 acquaintance groups vs. 8 nominal groups). The experimental design allows us to explore how team familiarity influences collaborative behaviors and decision-making process.

Methodology

1. Experimental Designs

Participants will work in pairs on three tasks, training, easy and difficult tasks. During the experiment, the participants have to develop strategies to fulfill the tasks requirements, in which participants collaboratively navigate a helicopter to avoid obstacles, visit destinations, and collect award flags. The level of task difficulty is decided by the number of flags and obstacles. Throughout the whole experiment, participants view the same screens and allow to discuss with each other to develop their strategies (figure 1). To collect the flags, the participants have to develop plans to fly the helicopter, where each round the helicopter can only move 10 steps to reach the destination. The order of assigning instructions by the participants is different. For example, in a total of 10 steps, one of the participants plans the first five steps, and the other issues the rest. These instructions are composed of an action with its duration, such as move forward for 5 seconds or hover for 3 seconds (figure 2). Since the helicopter does not fly in a constant velocity, participants can learn how to control the helicopter's speed and flying distance through trials and errors.

2. Research Methods

The correlation between team familiarity and task efficiency will be studied, where familiarity will be measured by a pretest that contains questions about participants' collaborative experience and how long they have known each other. The numbers of flags successfully collected will be the main measurement of task efficiency. In addition, behavioral and gaming data will also be collected by recording the entire experiment, allowing us to link subjects' operations and behaviors with their brain activities.

Based on the neuroscience perspective, EEG analysis is used to study the process of collaborative decision-making. This study synchronizes the participants' operations with their EEG signals, which link the variation of EEG signals to specific cognitive events. The EEG signals will be acquired via eight spiked dry electrodes based on the self-designed amplifiers. As shown and highlighted in figure 3, a total of eight electrodes are placed to study various regions of brain activities, including left frontal (F3), right frontal (F4), left central (C3), right central (C4), left parietal (P3), right parietal (P4), left occipital (O1), and right occipital (O3) [9].

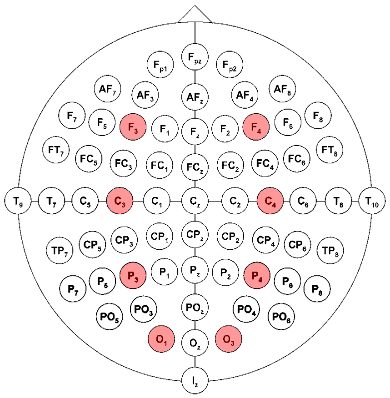

Figure 3: Electrode Map

Since an individual's logical thinking and decision-making process are the research focus, we observe the variation of beta wave (12-30 Hz) and low gamma wave (30-50 Hz), which respectively reflect brain consciousness and cognitive functioning [1, 5, 8]. In the data pre-processing stage, noises will be removed and the collected waves will be categorized based on four wave ranges: low beta (12.5-16 Hz), medium beta (16.5-20 Hz), high beta (20.5-28 Hz), and low gamma (30-50 Hz) [8]. By analyzing the frequency and amplitude of the waves, we can evaluate different brain activities and model its patterns, such as learning or problem-solving (table 1). Apart from the EEG signals, the AR system log and its associated behavioral data will also be collected, which allows us to study the connections between participants' actual behaviors and their brain activities.

Table 1: Brain waves and the activities they are involved in [1]

Low Beta (12.5-16 Hz)	Quiet, Focused, Introverted Concentration
Medium Beta (16.5-20 Hz)	Increases in Energy, Anxiety, and Performance
High Beta (20.5-28 Hz)	Significant Stress, Anxiety, Paranoia, High Energy, and High Arousal
Low Gamma (30-50 Hz)	Cognitive Functioning, Learning, Memory, and Information Processing

Expected Results

In this study, the acquaintance groups are expected to have a better overall performance than the nominal pairs. The potential reasons including less stress or smoother communication are likely to be investigated after interpreting the EEG signal patterns.

Future Research Planning

The present study applies eight EEG signals to examine brain activities. In future research, we plan to collect more EEG channels and explore the activity of different lobes of the brain to gain deeper insights of collaborators' decision-making process while engaging in collaborative tasks.

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