A Qualitative Analysis of Joint Visual Attention and Collaboration with High- and Low-Achieving Groups in Computer-Mediated Learning

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Abstract: While interest in using dual eye tracking sensors in computer-supported collaborative learning research continues to grow, it remains a challenge to know how to interpret the data these tools generate. This qualitative analysis leverages dual eye tracking data to offer Joint Visual Attention (JVA) graphs as a novel approach to depicting gaze synchronization, and presents a case study to provoke discussion around the opportunities to improve JVA graphs.

Introduction

Measuring collaborative learning is a difficult task, as collaboration is a continuous and multi-dimensional process (Meier, Spada, & Rummel, 2007). In situations of collaborative learning, however, Joint Visual Attention (JVA)––the tendency for social partners to focus on a common reference and to monitor one another's attention to an outside entity (Tomasello et al., 2005)—can act as a proxy for the quality of students' collaboration (Schneider et al., 2018). Additionally, researchers can now leverage emerging technologies, such as mobile eye tracking devices, to more rigorously measure students' levels of JVA. In this analysis, we leverage the massive datasets generated by mobile eye trackers to offer JVA graphs as an objective depiction of synchrony in students' gaze behaviors. We conclude by coupling two JVA graphs with observational data from a case study of two groups—who are similar based on their JVA levels, but differ in collaboration quality and learning gains—to open opportunities to improve JVA graphs.

Study design

This abstract focuses on the qualitative analysis of mobile eye tracking video footage collected from a subset of two dyad pairs, Groups 6 and 35 (N=4 out of 84), who participated in a previous empirical study (Schneider, accepted). Paired participants were asked to program a robot using a block-based programming language to navigate a series of increasingly difficult mazes in 30 minutes. The groups were selected based on two criteria: similarity in JVA levels and significant differences in learning gains scores compared to the whole study sample (n= 42 pairs). Group 6 had a learning gain score of 2 points and Group 35 had a learning gain score of 48 points, both on a 100-point scale.

Methods

Participants wore mobile eye trackers, and an automated system determined the location and proximity of participants' gazes. JVA graphs were generated for each dyad pair to depict the geometric proximity of participant gazes during the learning activity. Gaze proximity was counted as present whenever the distance between the two participants' gaze points was below a certain threshold (Schneider, accepted). Rising JVA lines indicate gaze convergence and falling JVA lines indicate the opposite (see Figure 1). We generated a qualitative codebook to categorize collaborative learning processes associated with high and low levels of JVA depicted by the graph. Two researchers independently coded a sample, and a Cohen's Kappa coefficient of 0.69 was reached indicating "good" agreement. Codes referenced in the case study below are illustrated by observational data in Table 1.

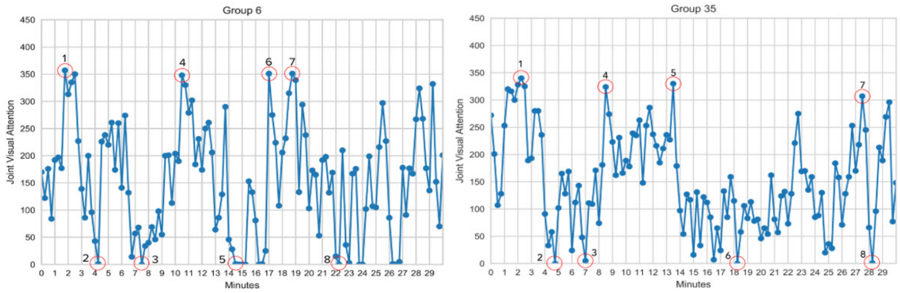

Figure 1. JVA graphs of two dyads during the 30-minute programming activity with examples of high and low JVA circled in red.

Case Study

In this section we present a case study to illustrate that high and low JVA levels are not always predictive of collaboration quality, and to identify promising indicators of quality collaboration as it relates to JVA.

Table 1: Qualitative observations (left) and quotes (right) showing differences in collaborative processes at high JVA (top row) and low JVA (bottom row) between Group 6 (low-achieving) and Group 35 (high-achieving)

Group 6 (low learning gains)	**Group 35 (high learning gains)**
High JVA: Gaze Following / Unbalanced Participation *<L tries to solve a sensor value problem>* Then for about 40 seconds there is complete silence. Though it seems as though she is struggling to find an answer to the sensor value question, Left does not ask Right, nor does Right volunteer any suggestions.	*High JVA: Coordinated Gaze / Thinking Aloud* *<R thinks aloud, builds common ground>* R: "It seems like the 'else' is probably forward. And [every time] we turn we want to have this (points to block) repeat. I forgot about that." *<without prompt, L agrees with R's ideas>* L: "Yeah, to go straight again."
Low JVA: Looking at Different Places / Unbalanced Participation The participant on the left picks up the cord to guide the robot. Left stands up to run code on robot. Right remains seated. It appears Right can neither see the robot, nor is trying to see the robot move. Meanwhile, Left watches the robot as it moves, and as she controls it.	*Low JVA: Looking at Different Places / Thinking Aloud* *<Dyad decides to use sensors to make the robot run>* R: "So we know now how to make it go straight and hit a wall. The question is, 'we need to know whether it goes right or left'. So, then, we might want to work with these sensors to determine what's on each side." *<R points to the sensors on the left and right sides of the robot>* L: "Okay…"

Analysis. Based on Table 1, we see at high JVA Group 6's collaborative learning processes (CLP) are characterized by gaze following and unbalanced participation where one participant actively works with the robot and the other is passive. Meanwhile, Group 35's CLP are characterized by thinking aloud and coordinated gaze where students share gazes due to verbal communication that helps them maintain their approach to achieve a shared goal and build common ground. At low JVA, Group 6 looks at different places during moments of unbalanced participation, while Group 35 engages in thinking aloud. This shows low JVA can also be an indicator of high-quality collaboration. Additionally, Group 6 spends most of their time in silence, while Group 35 often shows verbal activity. This observation suggests that thinking aloud is associated with a quality of collaboration that leads to high learning gains, while a tendency to engage in unbalanced participation is associated with a quality of collaboration that leads to low learning gains.

Conclusion

The JVA graph is an objective tool that provides a way for people to see different levels of synchronized gaze and rigorously measure students' JVA. Key indicators of quality of collaboration highlighted in the case study present an opportunity to discuss ways to improve JVA graphs, and even ideate new, compound visual representations that include key indicators of quality of collaboration and learning gains such as verbal activity, movement, and other multi-modal data streams.

References

Meier, A., Spada, H., & Rummel, N. (2007). A rating scheme for assessing the quality of computer-supported collaboration processes. *International Journal of Computer-Supported Collaborative Learning, 2*(1), 63–86.

Schneider, B., Sharma, K., Cuendet, S., (2018). Leveraging mobile eye-trackers to capture joint visual attention in co-located collaborative learning groups. *International Journal of Computer-Supported Collaborative Learning, 13*: 241.

Schneider, B.(accepted). Unpacking Collaborative Learning Processes during Hands-on Activities using Mobile Eye-Tracking. In *the 13th International Conference on Computer Supported Collaborative Learning.*

Tomasello, M., Carpenter, M., Call, J., Behne, T., & Moll, H. (2005). Understanding and sharing intentions: The origins of cultural cognition. *Behavioral and Brain Sciences*, *28*(05).