Do Cognitive Styles Influence Collective Sensemaking in Distributed Multiplayer Games?

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1. INTRODUCTION & BACKGROUND

Effective teamwork is characterized by having a shared understanding of objectives and collaboration skills [Salas et al. 1992]. In distributed multiplayer games, players need to constantly coordinate actions with each other and collectively make sense of the game objectives to succeed as a team [Alharthi et al. 2018b]. This is achieved by players processing and exchanging information among team members through game interfaces [Wuertz et al. 2018; Toups et al. 2014]. To better support collaborating in distributed multiplayer games, we need to understand the human factors that influence how teams collect, process, and share game information [Alharthi et al. 2018a; Raptis et al. 2016].

Team cognition is one of the human factors that influences collaboration [Gutwin and Greenberg 2004]. Each team member, based on their unique cognitive characteristics, develops a specific approach to process information and engage in both individual and collective sensemaking activities [Weick 1995]. *Sensemaking* is a process performed in order to understand a situation and make decisions [Weick 1995]. The need for sensemaking arises in shifting environments, when new challenges, opportunities, and tasks are emergent [Toups et al. 2016]. *Information seeking* is an essential part of the process of collective sensemaking, in which information are collected, shared, filtered, processed, authenticated, and interpreted to extract what is needed to understand a situation and effectively work together as a team [Weick 1995].

Individuals develop different approaches to collect and process information in complex environments. Such different approaches are known as *cognitive styles* [Kozhevnikov 2007]. A well-known cognitive style is *Field Dependence—Independence (FD-I)*, which identifies two extremes: *field dependent (FD)* – integrating information from surrounding context – and *field independent (FI)* – able to separate visual information from surrounding context [Witkin et al. 1977]. Considering that people with disparate cognitive styles process information differently, cognitive styles are expected to play an important role in the success of teamwork and how teams engage in collective sensemaking activities in distributed multiplayer games [Chujfi and Meinel 2015].

Based on our motivation and study of related work [Hong et al. 2012; Witkin and Goodenough 1976; Nisiforou 2015; Raptis et al. 2016; 2018; Michailova and Sidorova 2011], we expect people characterized as FI to be beneficial to teams playing games that involve seeking, processing, and sharing information, as they tend to deconstruct complex scenes faster [Witkin and Goodenough 1976], perform fewer but more accurate movements [Hong et al. 2012], adopt a more exploratory information seeking strategy [Raptis et al. 2016], be more engaged in enriched visual contexts [Raptis et al. 2018], and are less dependent on contextual cues and visualized guiding information [Michailova and Sidorova 2011].

2. METHOD

To identify whether FD-I cognitive style influences teams' collective sensemaking in distributed multiplayer games, we conducted a mixed-methods, between-subjects study (see [Alharthi et al. 2018a]). We used the *Team Coordination & Planning Game (TeCP)*, a distributed multiplayer cooperative game for two players [Alharthi et al. 2018b]. The design of the game was based on different game design patterns that help engage players in collective sensemaking and planning activities [Toups et al. 2016]. A core feature of the game is that it requires players to collaborate and engage in collective sensemaking through interfaces and game mechanics that facilitate information seeking, planning, and problem-solving. Players in *TeCP* are able to move their avatars in all directions and carry, place, and stack cubes to complete the different collaborative tasks. Dependencies in the game force players to collect different pieces of information from the gameworld and share them with their teammates to develop plans and succeed in the game.

The study was carried out in an ecologically valid environment for gameplay: an internet/games café. The study participants were customers of the café, they had never played *TeCP* game, but were familiar with such type of games. Through this study, we empirically evaluate how cognitive styles influence teams' information-seeking and sharing behavior. To form the study teams based on their FD-I cognitive style, as a first step, we classified the participants as either FD or FI. We used the *Group Embedded Figures Test (GEFT)* [Oltman et al. 1971] as the classification tool. After the classification of each participant, they were allocated in the teams. In total, we formed three types of dyadic teams: FD-FD, FD-FI, and FI-FI. We used a between-subjects design with a single independent variable: team type, with three levels representing the different combinations of teams and cognitive styles. The dependent variables were: time taken to complete the game, scores on the NASA-TLX cognitive workload measures, scores on the Player Experience Inventory (PXI), and annotation use counts. For more details regarding the study and method, see [Alharthi et al. 2018a].

3. RESULTS & DISCUSSION

The study results (Figure 1) show that FD-FD style teams had poor performance (in terms of time spent to complete the game), had an increased mental workload, and had an increased frustration, despite communicating verbally and with visual annotations. The main reason for such results is that FD-style players faced difficulties in distinguishing details within the complex visual scenes of the game, and thus, it limited the efficiency of the team. On the other hand, FI-style players did not face such difficulties, and thus, the teams that had at least one FI-style player (i.e., FD-FI and FI-

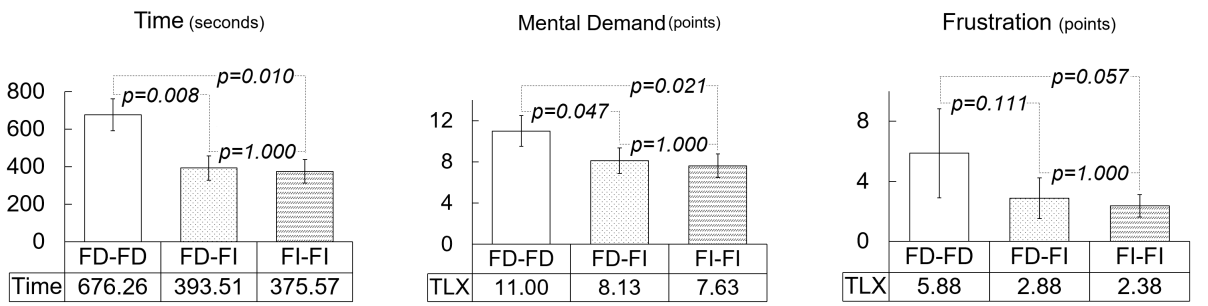

Fig. 1. **(left)** FD-FD group needed more time than FD-FI and FI-FI groups to complete the game; **(middle)** FD-FD group found the task more mental demanding than the other groups; **(right)** FD-FD group found the task more frustrating than the FI-FI group [Alharthi et al. 2018a].

FI teams) performed better, as they spent less time to complete all collaborative tasks and finish the game. We attribute this to the ability of FI-style players to easily identify different information in the game, locate game targets, and find a way to accomplish the goals within the visually complex game background.

FI-style players adopted an independent exploration approach and followed separate paths (from their teammates). Hence, they helped their teams (i.e., FD-FI and FI-FI) to explore the gameworld, identify the critical areas of the scene, and give meaning to them more quickly than FD-FD teams. Regarding FD-FD teams, FD-style players were more reluctant to deviate from the information-seeking strategy agreed with their teammates, were exploring the gameworld in dyads, and were focused on the overall game goal. As a result, FD-style players, especially in FD-FD teams, spent more time than FI-style players to make sense of the gameworld and identify the actions required to accomplish their goals, both because of their inherent difficulty to separate visual information from surrounding context and because of the fact that they might not have explored the whole scene. As a result, FD-FD teams found the collaborative tasks to be mental demanding and frustrating.

Regarding the communication tools, all teams used dialogues to communicate, with teams that had at least one FD-style player having more explicit and clear dialogues, as FD-style players tend to seek maximum amount of guidance and clarity from their teammates [Chen and Liu 2008]. FD-FI teams used more frequently a combination of verbal and non-verbal communication tools to collectively make sense of the game situation and plan their next steps.

According to our results, *cognitive styles do influence collective sensemaking in distributed multiplayer games*, and thus, they should be considered as a human factor in the formation of teams in such games and as a main factor in player-centered game design [Sykes and Federoff 2006]. Based on these results, in multiplayer collaborative games that require demanding information seeking and sharing, cognitive styles should be considered as a human factor that influences how teams collaborate and perform. In our example, forming teams that combines both FD- and FI-style players will help teams to have an increased performance in time-dependent tasks and demanding/stressful contexts.

Our work has implications for player-centered game design, as differences in player's cognitive styles and their impact on collective sensemaking and performance call for new and innovative game designs. *Cognition-based adaptive games* could benefit individuals with different cognitive characteristics to more efficiently seek and share information, helping them to improve their teamwork. For example, different personalized tools and mechanics can be used, such as automated navigation assistance tools [Johanson et al. 2017], diversity of annotation tools [Alharthi et al. 2018b], awareness cues [Wuertz et al. 2018], and cooperative communication mechanics [Toups et al. 2014], which aim to support information seeking and collective sensemaking between team members. To help players with cognitive differences to fully participate and actively engage with tasks that do not favor their inherent characteristics, games could support collective sensemaking and information seeking through cognition-tailored collaborative schemes, improving accessibility in games. Overall, forming cognition-diverse teams and providing different cognition-adaptive interfaces could lead to better teamwork, enhancing performance in multiplayer games.

4. CONCLUSION

These findings suggest that — when the goal is to improve performance — cognitive styles should be one of the human factors considered in designing collaborative games and forming effective teams. We argue that this work contributes new and novel insights and implications that could influence future design and research in supporting collaboration in distributed multiplayer games.

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