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# The influence of the shared-display configuration on group decision making

Qin Gao*, Xing Chen, Zhizhong Li

*Department of Industrial Engineering, Tsinghua University, Beijing 100084, China*

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ABSTRACT

Large shared displays are increasingly being used to support co-located group decision-making tasks. The expectation is that they can provide a shared visual reference and facilitate interaction between decision makers. This study examined the impact of shared-display configurations on group decision-making processes and outcomes. Three design factors were examined: submission control, display control, and presenting predictions on shared displays. Sixty-four participants performed an optimization task in groups of four members that were supported by different shared-display systems. The results show that submission control has a positive impact on the level of participation, the satisfaction with the group process, and the commitment to the decisions made, but it negatively influences the decision quality; presenting predictive information on the shared display, which is separated from the current information on the personal displays, has a negative impact on the group process and decision quality. In addition, the participants tend to always display all of the information that is available on the screen, in spite of the provision of the display control option.

*Relevance to industry:* How group members can control the content on the shared displays and on their personal displays would influence the group behavior. Gained knowledge from this study is useful for designing and configuring shared-display systems for better group decision-making support.



## 1. Introduction

The recent technology development and decreasing cost of displays has brought a growing interest in situating large shared displays to support a variety of co-located collaborative work in various domains, such as manufacturing plants (Wallace et al., 2009), healthcare services (Wilson et al., 2006; Kane et al., 2013), scientific research and tasks (Huang et al., 2007; Reda et al., 2014), and education (Chung et al., 2013; Kreitmayer et al., 2013). Stewart et al. (1999) first introduced the concept of supporting co-located collaborative work via a shared display. He proposed a model of single display groupware in which group members have separate input devices, but the output channel is shared. The concept was extended to denote shared-display groupware (Ryall et al., 2004) and multi-display groupware (Inkpen and Mandryk, 2005; Wallace and Scott, 2008; Wallace et al., 2009). In contrast to the idea of single display groupware, these systems consist of multiple connected personal and public displays. Such systems provide users with personal workspaces with which they can break off from a collective task. The provision of both personal and public workspace was considered to be useful to prevent the social discomfort of using one single display (Wallace et al., 2009). Although different in the exact details of the technical composition, these systems all involve the use of large shared displays to support collaborative work among people who are physically close to each other.

Many shared-display projects have attempted to make an interactive environment for better group decision making (Borchers et al., 2002; Yang and Lin, 2010; Kane et al., 2013; Burtscher and Meyer, 2014; McGill et al., 2014). Information from different group members can be collected together on a shared visual reference point and can be easily accessed with better visibility and readability at a distance. With a large wall display, an at-a-glance view of the most critical information is often supported. The ability to see and interact with more data at once has been found encouraging users' to explore the data more broadly (Reda et al., 2014; Sakuraba et al., 2014) and supporting users' side tasks under high information processing needs (Pennathur et al., 2011). During the discussion, each member can also interact with the shared display through clients on their personal devices, such as mobile computers or PDA. The ability to interact with other members on a single screen has been found increasing verbal

* Corresponding author. Tel.: +86 1062781165; fax: +86 1062794399.
*E-mail address:* gaoqin@tsinghua.edu.cn (Q. Gao).

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discussions and improving collaboration whereas preserving independence (McGill et al., 2014; Chung et al., 2013; Kreitmayer et al., 2013). Thus, the shared-display systems provide value both as a passive information display and as an interaction tool. Such a system design is expected to combine the richness of face-to-face communication and the advantages of digital technologies (Pavlovych and Stuerzlinger, 2008). In many complex and dynamic systems where there are large amounts of data that must be exchanged and processed within a short period of time, decision makers must retrieve, comprehend and combine information from different persons and from different displays. Without a proper design, the increased number of displays and interaction channels could lead to even more severe information overload and higher interaction overhead, which could be detrimental for the group process and the final decision quality.

There has been a long history of research on computer-supported decision making for distributed groups. On the one hand, research has consistently found that compared with face-to-face groups, computer-mediated groups exchange less information in the decision-making process (Hedlund et al., 1998; Hiltz et al., 1986; McGuire et al., 1987), as indicated by both a lower frequency and a smaller amount of information. This circumstance has been referred to as information suppression (Hollingshead, 1996; Hollingshead et al., 1993) and was often attributed to the low richness that computer-mediated communication can provide (Daft et al., 1987). On the other hand, computer-mediated groups were found to share more task-oriented information (Hiltz et al., 1986) and generate more diverse opinions (Dennis et al., 1997; Weisband et al., 1995). Some researchers attributed the diverse opinions generated via computer-mediated communications to the reduced social cues that inform about status in the group and consequently a sense of anonymity (Baltes et al., 2002; Dennis et al., 1997). With regard to the decision quality, although the majority reported no influence or a negative influence of computer-mediated communications (Hiltz et al., 1986; Hollingshead, 1996; Straus and McGrath, 1994), some research also found evidence for positive effects of computer-mediated communication (Benbunan-Fich and Hiltz, 1999; Smith and Hayne, 1997). The mixed findings could be attributable to differences in the relative importance of the information exchange and the required effort for resolving conflicts with regard to the type of task the group is working on (Baltes et al., 2002; Hedlund et al., 1998).

These studies investigated distributed groups that utilize text-based messages and/or video conferencing technologies. The group process can be very different between such a setting and the co-located groups who are utilizing a shared-display system. For example, in the latter setting, the problem of reduced richness and the effect of anonymity do not exist at all. How the use of computer support can influence the decision-making process for co-located groups remains largely unexplored. Several researchers examined the impact of various configurations of shared-display systems, including the physical affordance of shared displays (such as the size and the orientation) (Pavlovych and Stuerzlinger, 2008; Rogers and Lindley, 2004; Ryall et al., 2004), the single-/multiple-display configuration (Wallace et al., 2009), the access control and input devices (Pavlovych and Stuerzlinger, 2008; Kim and Snow, 2013), and the practical barriers in implementing the systems in reality (Huang et al., 2007; Kane et al., 2013). A couple of recent studies have explored the use of a shared display for presenting team-related information, such as team members' knowledge and skills, participation levels, and the group focus (DiMicco et al., 2004; Romero, 2013). However, most of these studies focused on tasks that address a well-defined problem in a static environment and that involve rare group conflicts. The impact of shared-display configurations on group decision-making tasks in a dynamic environment with inherent conflicts between group members has rarely been examined.

This study aimed at understanding the impact of shared-display configurations on group performance in a dynamic decision-making task that required group members both collaborate and compete with each other. Specifically, we were interested in the level of control that group members have over the information representation and submission while using such a group decision aid. User control has been identified as a core dimension of interactivity in computer-mediated communications (Bezjian-Avery et al., 1998; Jensen, 1998; Steuer, 1992; Park et al., 2013). It refers to the extent to which an individual is authorized to control the functions and the appearance of the system (Dholakia et al., 2000; Park et al., 2011). With regard to shared-display systems, we examined two types of controls that were likely to influence the users' behaviors and consequently the group decision-making process: submission control and display control. Submission control refers to whether the users can submit decision alternatives at their own initiative to the shared display or, alternatively, the large display will show every modification of their alternative that they have in real time. Display control refers to whether the users can select the type of information to display and also the display format. Previous research found that a higher level of user control was related to better memory, higher self-efficacy, and better learning, which results from having a maximized mapping between the information demand and supply (Ariely, 2000; Mitchell et al., 1994). Bezjian-Avery et al. (1998) found that it took decision-makers less time to decide whether to buy the product in a more controllable interactive advertisement. Active control requires decision-makers to become more mentally involved in order to actively make decisions (Liu and Shrum, 2002). We expected that this high involvement would lead to a higher level of participation of individuals in the group decision process, which has been found to contribute to a higher commitment to the decision that is made and a better decision quality (Bass, 1981; Locke and Schweiger, 1979). In addition, the display control allows users to display information that is useful and relevant at the time, in the format that they prefer. We expected that the provision of display control could help the users to reduce the information overload when addressing a large amount of dynamic information in the decision-making process.

In addition, we also examined the impact of providing extra predictive information about the shared display on the performance of the dynamic decision-making task. To make decisions with dynamic information, decision makers must make predictions that are based on the historical trends in the system status changes. Prediction is a mental effort that is difficult to perform well. A number of researchers have explored the possibility of presenting predictive information to users, through numeric or graphic representation, to support their awareness of the system status and their projection into the future state (Endsley et al., 1999; Yin, 2012; Yin et al., 2008). These studies, however, presented predictive information together with the current system status on a single display for individual users. In this study, we explored the possibility of using the shared display as a standalone predictive display. Whereas prediction information is useful for the task, the users must incorporate and compare information from different displays, which could add to the task load. We were interested in whether such a configuration, which presents extra predictive information on the shared display for the group, has a positive or negative impact on the group process and the decision quality.

In this study, we examined the impact of submission control, display control, and predictive information on the shared display on group decision-making tasks. Sixty-four participants were invited to perform an optimization task in groups of four. The