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The Impact of User Interface Design on Idea Integration in Electronic Brainstorming: An Attention-Based View

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Abstract

This paper introduces an attention-based view of idea integration that underscores the importance of information system (IS) user interface design. Presenting ideas via an IS user interface can play an important role in enabling and motivating idea integration in electronic brainstorming systems (EBS), and thus can improve productivity. Building on a cognitive network model of creativity and the ability-motivation framework, our attention-based view focuses on two major attributes of a user interface: visibility and prioritization. Visibility enables idea integration by directing individuals' attention to a limited set of ideas, and prioritization enhances the motivation for idea integration by providing a relevant proxy for the value of the shared ideas. The theory developed in this paper is distinct from previous research on EBS in at least two ways: (1) it focuses on idea integration as the desired outcome, and (2) given that EBS do not universally outperform verbal brainstorming, the proposed theory revisits the links between user interface and idea integration. Idea integration in groups is an attention-intensive process that is essential for organizational creativity and thus for establishing knowledge-based capabilities. A lack of integration can significantly reduce the value of idea sharing, which has been the main focus of the EBS literature. Our theory posits that the ability of electronic brainstorming to outperform nominal or verbal brainstorming depends on its ability to leverage the capabilities of the IS artifact for enhancing idea integration. Our theory provides a foundation for new approaches to EBS and computer-mediated collaboration research. The emphasis on idea integration provides designers and managers of EBS with practical, cognition-based criteria for choosing interface features. Our theory also has implications for the practice and research of knowledge management, especially for the attention-based view of the organization.

Keywords: *Idea Integration, Visibility, Prioritization, Attention-Based View, Electronic Brainstorming Systems.*

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1. Introduction

Brainstorming, defined as generating, sharing, and combining ideas about a problem or task by more than one individual (Reinig, Briggs, & Nunamaker, 2007; Shepherd, Briggs, Reinig, Yen, & Nunamaker, 1996), has long been supported by electronic media. The reported benefits of electronic brainstorming systems (EBS) include cognitive stimulation and synergy, reduced production blocking, and reduced evaluation apprehension in anonymous EBS (Briggs, 2006; de Vreede & Dickson, 2000; Fjermestad & Hiltz, 2001; Pinsonneault, Barki, Gallupe, & Hoppen, 1999). Shepherd et al. (1996), for instance, report a 63 percent increase in the number of unique ideas generated during a brainstorming session when a highly salient social comparison mechanism was utilized in the brainstorming.

Despite the benefits, evidence from research and practice also suggests that EBS may at times offer limited benefits regarding the quantity and quality of the ideas generated during the brainstorming process (Fjermestad & Hiltz, 1999, 2001). Process losses pertain in particular to attention-based issues and cognitive interference (Pinsonneault et al., 1999). For example, an experimental study at Sandia National Laboratories (Davidson et al., 2007) found that individuals working alone outperformed those working in groups in terms of the quantity of ideas generated and the extent of the elaboration of each idea.

Two factors in particular seem to contribute o losses from inefficient attention processes: (1) attention diversion because of excessive exposure to other people's ideas, and (2) lack of attention on other people's ideas. With the theory presented in the current paper, we intend to contribute to EBS's productivity with guidelines that can improve attention while limiting process losses. We apply user interface design as our lens with an emphasis on idea integration as a desired outcome (de Vreede, Briggs, van Duin, & Enserink, 2000; Dennis, 1996; Robert, Dennis, & Ahuja, 2008; Sussman & Siegal, 2003).

We view idea integration here as an explicit reference to and use of the evidence that is presented in the ideas of a partner, and as closely related to information adoption and use. Previous research studies have found that an organization's ability to appropriate the value of knowledge owned and accumulated by individuals (Grant, 1996b; Kogut & Zander, 1992; Santanen, Briggs, & de Vreede, 2004) depends critically on the organization's ability to encourage idea integration in groups (Okhuysen & Eisenhardt, 2002), particularly diverse groups.

However, with few exceptions (e.g., de Vreede et al., 2000; de Vreede, Briggs, & Reiter-Palmon, 2010; see Table 1 on page 10), the dominant focus in EBS research has been on the determinants and the detriments of idea sharing, with little consideration for the ultimate goal of shared ideas being integrated and used by others. The broader research literature on brainstorming compares the productivity of nominal brainstorming, where individuals ideate on a problem separately, with that of verbal brainstorming, where individuals ideate on a problem collaboratively in groups, although idea integration is not always regarded as an essential measure of brainstorming productivity (Fjermestad & Hiltz, 1999, 2001). Some research, however, regards idea integration as a primary contributor to productivity gains in groups (de Vreede et al., 2000, 2010; de Vreede, Davison, & Briggs, 2003), and has noted that the antecedents of idea integration typically differ from, but sometimes overlap with, those of idea generation and sharing (de Vreede et al., 2003; Santanen et al., 2004). Also, several experimental studies have addressed individual idea integration behavior and have measured the extent to which individuals build on the ideas shared by others (de Vreede et al., 2010; Dennis, 1996; Robert et al., 2008).

To bridge the identified gap in the research literature, our proposed theory focuses on idea integration to improve EBS productivity (Dennis, 1996; Homan, van Knippenberg, Van Kleef, & De Dreu, 2007; Robert et al., 2008). For ideas to be integrated, they must be exposed to individuals' attention; and because individuals must create the connections among different ideas, they must be motivated to do so. To capture these two traits, we apply an attention-based view of user interface influence on idea

integration (Ocasio, 1997; Simon, 1947) that builds on the premise that idea integration in electronic brainstorming depends on the extent and quality of attention allocated to the shared ideas. In addition, we build on the cognitive network model of creativity (Santanen et al., 2004) because we adopt a motivation-ability approach to interface design (Roberts & Dennis, 2005; Santanen et al., 2004; Thoemmes & Conway, 2007). For this second part, we build on the premise that attending to shared ideas leads to the retrieval and activation of related concepts in memory, which advances the potential for idea integration (Santanen et al., 2004).

Because the user interface is the main point of access to the shared ideas (Sheppard & Rouff, 1994), we suggest that its features play a key role in channeling individuals' attention and in enabling and motivating idea integration (Dennis, Wixom, & Vandenberg, 2001; Suedfeld, Tetlock, Streufert, 1992; Thoemmes & Conway, 2007). More specifically, we suggest that the manipulation of idea visibility can help to channel individuals' attention (Briggs, 1995), and the prioritization of ideas can influence idea integration behavior (Dennis, 1996). Therefore, the developed theory accounts for processes underpinning idea integration, and uses the IS artifact as an instrument to cultivate the potential for idea integration (Briggs, 2006).

Despite its focus on the IS user interface, the proposed theory is technology independent in that the effect of the interface-based constructs (i.e., visibility and prioritization) on idea integration is explained through the processes that shape idea integration behavior, rather than through a specific technological implementation (Briggs, 2006).

The current paper contributes to the IS research literature on EBS and idea creation in at least three ways. First, building on Simon's (1947) logic for attention as a scarce resource in organizations, it links IS interface attributes to the creation of organizational knowledge-based capabilities in an era of collaboration technology prevalence (McAfee, 2006). Second, by building on the EBS literature, it extends the use of interface attributes for enhancing brainstorming productivity as it promotes idea integration (de Vreede et al., 2003; Dennis, Valacich, Connolly, & Wynne, 1996). Third, it creates the foundation for empirical studies that contribute to technology design and managerial decision making on the choice of technologies to improve collaboration within organizations (Briggs, 2006; Zhang & Watts, 2008).

In addition, the guidelines derived from our developed theory in the context of electronic brainstorming will apply to computer-mediated communication (CMC) in any context where knowledge creation is the goal. Our theory proposes methods for making EBS in particular, and CMC in general, more amenable to idea integration. The theoretical propositions derived from our developed theory lead to testable hypotheses in field or laboratory experiments.

Because IS theories are expected to focus on technology-supported processes rather than just the technology (Briggs, 2006), we first expand on idea integration processes and dynamics. We note the links between idea integration and EBS productivity and we proceed to present our attention-based view of idea integration. We then consider the links between IS user interface features and idea integration (Mitchell, 2006). The remainder of the paper conceptualizes each of the constructs in our theory.

2. Idea Integration and Electronic Brainstorming Productivity

Brainstorming involves the generation, sharing, individual-level processing, and integration of ideas (Homan et al., 2007). In cases where no one individual has sufficient information to generate the best solution to a given problem or task, it follows that idea integration is key to more fully realizing the value of the shared ideas (de Vreede, et al., 2003; Dennis, 1996; Robert et al., 2008). If individually generated ideas are not attended to, processed, and used by the recipients, idea sharing will not provide any benefit (Grant, 1996b; Zhang & Watts, 2008).

Some research studies of EBS have included idea integration in the measurement of group productivity and have implemented mechanisms, such as the relay method, for improving idea integration. In the relay method, individuals in a group are organized into subgroups and are engaged in the brainstorming process in a sequential form, whereby subgroups are instructed to start the ideation process where the previous subgroups ended (de Vreede, Briggs, van Duin, & Enserink 2000; de Vreede, Briggs, & Reiter-Palmon, 2010). Interestingly, the relay groups were found to be more productive than their counterpart, decathlon groups, in which sub-groups worked in a parallel manner (de Vreede et al., 2000, 2010). The productivity gain was mainly associated with higher elaboration on others' ideas rather than with an increase in the number of unique ideas. Still, empirical studies also indicate that integration does not occur automatically and that individuals must be able and motivated to integrate ideas (Homan et al., 2007; Santanen et al., 2004). In the following paragraphs, we take a closer look at idea integration and its related concepts.

Idea integration is a critical pattern for knowledge creation by which dimensions of more than one individual's ideas are combined to create new and more integratively complex ideas (Okhuysen & Eisenhardt, 2002). It is also the combination of explicit knowledge items (Nonaka, 1994; Patanayuki, Ruppel, & Rai, 2006) that occurs when individuals consider some or all dimensions of others' ideas (recognition) and create conceptual connections among different dimensions (integration) (Gruenfeld & Hollingshead, 1993). In IS studies, idea integration has typically been posited to be complementary to idea generation and sharing (Dennis, 1996).

In the current study, we conceptualize the construct of an idea as a basic element of thought that is represented by verb-object combinations and consists of at least one testable proposition (de Vreede et al., 2000; Simon, 1947), such as "solution A is better than solution B because it is more scalable". This definition of an idea thus excludes normative statements such as: "I prefer solution A", or "I believe we should adopt solution B" (Simon, 1947). Furthermore, if the verb-object combination is a definition or description of an object, event, or process that does not include the individual's perspective on it and does not provide any indication of relevance to the topic discussed in the group, it is also not considered an idea (Baker-Brown et al., 1992). An example of such a descriptive statement is: "Well, we are 65 miles off course and we know we are S - SW of the mining camp", which could be made during a brainstorming session on how to survive in the desert. So, effectively, we exclude two forms of verb-object combinations from our definition of an idea; namely, purely normative and purely descriptive statements. We still consider a statement an idea, however, if it is a mixture of normative statements and testable propositions. For example: "I think some sort of tarp should be used because it provides shade and shelter" is an idea that could be offered during the desert survival brainstorming session.

Idea integration in the IS research literature has been conceptualized as the explicit reference to the ideas of partners in the form of comments, and has been categorized as a measure of communication in the category of effectiveness measures (Fjermestad & Hiltz, 1999, 2001). Other IS research studies have used constructs that are closely related. For example, elaboration has been defined in EBS studies as the task-relevant reference to previously generated ideas, and is measured as the extent to which discussion takes place during electronic meetings (de Vreede et al., 2000, 2010). The outcome of elaboration has been identified as knowledge integration, which is described as information exchange and information processing at the individual level, followed by integration at the group level (Homan et al., 2007, see Table 1). Also, related to integration are information adoption and use because they involve attending and appropriating task-relevant shared information during task performance (Dennis, 1996; Ferran & Watts, 2008; Sussman & Siegal, 2003). Table 1 provides an overview of related research studies.

Table 1. Studies of Idea Integration

Study	Dependent variable	Construct definition	Approach
Dennis (1996)	Information use	Use of unique information owned by others	Information recall-exchange-processing and use theory
de Vreede et al. (2000, 2010)	Elaboration	A task relevant reference to a previously submitted unique idea, such as a comment	Relay (serial) vs. decathlon (parallel) sub-groups
Okhuysen & Eisenhardt (2002)	Knowledge Integration	Use of unique knowledge pieces owned by others	Use of formal interventions for directing and switching attention
Sussman & Siegal (2003)	Information adoption	A manifestation of knowledge internalization in organizational advice-receiving contexts	Adoption and information influence theories
Homan et al. (2007)	Information elaboration	Elaboration on task-relevant information and perspectives	Pro-diversity as integration enabler
Robert et al. (2008)	Knowledge integration	Making reference to other's ideas	Social capital theory

In this paper, we apply the construct of idea integration with an emphasis on combining different ideas, and we focus on the level of analysis "in groups". Idea integration occurs when an individual refers to the ideas proposed by others, and tends to lead to integratively complex ideas (de Vreede et al., 2003; Robert et al., 2008) in which conceptual connections are made between one's own ideas and the ideas of others (Gruenfeld & Hollingshead, 1993; Santanen et al., 2004). For example, during the discussion on desert survival, one individual might propose the idea that "Having a medical first-aid kit from the plane would help". A second individual responds: "Having a medical first-aid kit is a good idea but in the survival problem description they said we were not hurt". By making explicit reference to the idea of the first individual and relating it with her own, the second individual has just engaged in idea integration. The result is conceptually more complex than the original idea.

In our understanding of idea integration, reference may be made to an idea as a whole or to one or several of its dimensions. Even though dimensions are considered building blocks in the study of idea integration (Suedfeld et al., 1992), we are not aware of previous research studies that have explicitly defined them. We thus define an idea dimension as a unique testable proposition. We call a shared piece of information a multi-dimensional idea if it includes more than one unique testable proposition, such as the following example from the desert survival task: "Some sort of outer shell jacket that is water proof can be used to collect water if it rains and to help cover our body at night".

Different levels of idea integration contribute to brainstorming productivity in different ways. While not classified as an idea in the current paper, the basic level of integration, indicated by purely normative statements such as "I agree", is nonetheless believed to be important in corroborating the idea that is being referred to (de Vreede et al., 2000, 2010). Our definition of idea integration and the distinction between different levels of idea integration ranging from mere reference to others' ideas to fully

integrating others' ideas with those of their own in the current theory is based on the well-studied concept of integrative complexity in social psychology (Baker-Brown et al., 1992; Suedfeld et al., 1992). Integrative complexity measures the tendency of an individual to consider relevant information from more than one dimension and includes two phases: (1) differentiation, which is the perception of different aspects of a subject; and (2) integration, which is the recognition of connections among those aspects (Suedfeld et al., 1992). Research studies have distinguished between the state and the trait of integrative complexity. We view idea integration as a "state of integrative complexity" that is expected to change in response to environmental mediators and interventions (Suedfeld et al., 1992).

Distinguishing among different levels (degrees) of idea integration is useful for several reasons. First, it allows for flexibility in the operationalization of idea integration in groups. With few exceptions (de Vreede et al., 2000, 2010), empirical studies have focused mainly on the quantity of integration as measured by the number of references made by individuals to the ideas of others (Homan et al., 2007; Robert et al., 2008). However, because different combinations of the same factual information (testable propositions) may generate different combinative outcomes (Okhuysen & Eisenhardt, 2002), measuring levels and quality of idea integration is important when examining the value created by idea integration (de Vreede et al., 2000). Second, the level and quality of idea integration at the group level influence the value of knowledge integration at the organizational level. We suggest that a distinction between different levels of idea integration can bring richness to the theory and can facilitate more precise empirical testing. Such research can then improve the link between idea integration in groups and the creation of organizational knowledge-based capabilities (Santanen et al., 2004). Building on our developed definition of idea integration, the next section describes our proposed attention-based view.

3. The Attention-Based View

The attention-based view developed here is based on Herbert Simon's logic of attention as a scarce resource (e.g., Simon, 1947; March & Simon, 1958). Our assumption is that attention is an essential element for the initiation of idea integration in groups, and that, in electronic groups, the user interface can help manage the associated attention-based processes.

In the attention-based view of the firm, the desired process is called a move (Ocasio, 1997) and is defined as an intentional process that is shaped by individuals. Desired moves can be nurtured through regulating forces, such as organizational rules, which channel an individual's attention through valuation and motivation. In the current study, the integration of individual ideas in groups constitutes the desired move that must be valued and motivated, and can be enabled with IS interface features.

The attention-based view developed here is informed in particular by the cognitive network model of creativity (CNM) and the ability-motivation framework (Santanen et al., 2004; Thoemmes & Conway, 2007). We explain both approaches in Sections 3.1 and 3.2 with respect to our developed theory.

3.1. Cognitive Network Model of Creativity (CNM)

CNM is viewed as a foundation for understanding causality in the context of creativity, and is based on principles of retrieval from long-term memory and activation in working memory. This approach is related to our view of idea integration as a specific form of creativity that relies on perceiving different dimensions of the shared ideas, retrieving relevant concepts from long-term memory, and creating novel combinations among the perceived and activated concepts (Santanen et al., 2004). Because CNM has developed a causal relationship between the extent, frequency, and diversity of the cues presented to individuals as the input and the creativity level as the outcome, it has been applied widely to the design of collaboration processes with predictable outcomes (Kolfschoten, de Vreede, Briggs, & Sol, 2010). Also, CNM has been used to design effective facilitation mechanisms that warrant more creative group outcomes (Santanen et al., 2004).

CNM posits that creativity is initiated when individuals search in long-term memory "knowledge maps" using cues that are made available to them through external stimuli. Relevant frames are then

transferred from long-term memory to working memory and creativity occurs when links among originally distant frames are created (Briggs, 2006; Santanen et al., 2004). In addition to automatic aspects of search, retrieval, and activation, idea integration requires individuals to be "mindful" (Driver & Streufert, 1969; Langer, 1989; Levinthal & Rerup, 2006; Santanen et al., 2004). Mindful individuals are present-oriented and able to distinguish between different perspectives available to them (Butler & Gray, 2006; Langer, 1989). Mindfulness, therefore, empowers associative thinking (Osborn, 1953; Potter & Balthazard, 2004) by enhancing the recognition of different dimensions of the shared ideas, which then invokes searching in one's memory using cues contained in those ideas and the retrieval of related concepts. Mindful individuals are also open to novelty and are able to compare, contrast, and make judgments (Butler & Gray, 2006; Weick, Sutcliffe, & Obstfeld, 1999). Therefore, mindfulness empowers integration by facilitating the creation of connections among the retrieved concepts, too (Gruenfeld & Hollingshead, 1993).

CNM also posits that the creativity process just described can be manipulated to some extent. When ideas are presented to individuals and are attended to, memory traces of related concepts become more active and therefore the connections among those ideas are more likely to be discovered. This discovery happens because, in associative memory, the frames that are initially retrieved and activated instigate what is activated next (Anderson, 2005; Santanen et al., 2004). To the extent that the environment encourages complex thinking and motivates idea integration (e.g., in a brainstorming process), those connections are likely articulated as combinative ideas. Because each idea that an individual attends to provides a potential set of cues that can be used during the subsequent memory search process (Potter & Balthazard, 2004), the number of potential cues, and as a result the level of activation, increases as the number of visible ideas increases. However, similar to what happens in many Web 2.0 knowledge-sharing applications (e.g., Yahoo Answers and Mail.ru) an abundance of information can also divert an individual's scarce resource of attention and overwhelm the available cognitive resources (March & Simon, 1958; Potter & Balthazard, 2004; Santanen et al., 2004). We suggest that the IS user interface can help to overcome such attention diversion and to better manage an individual's attention.

3.2. Ability-Motivation Framework

The idea underpinning the ability-motivation framework is that, for idea integration to occur, individuals must be both able and motivated to combine their ideas with those of others (Butler & Gray, 2006; de Vreede et al. 2003). Idea integration requires complex thinking (de Vreede et al., 2000; Gruenfeld & Hollingshead, 1993), which is not only a matter of ability, but also a matter of motivation (Thoemmes & Conway, 2007). Situational conditions such as environments that reward complexity are thought to influence the level of state complexity (Homan et al., 2007; Suedfeld et al., 1992). We propose that complex thinking and idea integration can be enabled and motivated via the IS user interface (Suedfeld et al., 1992).

Idea integration comprises two phases: differentiation and integration. During differentiation, an individual perceives the different dimensions of a shared idea, which requires processing the information that is contained in those ideas. Two different routes are available for information processing (Dennis, 1996): (1) The central route applies when the individuals themselves assess the information contained in the ideas they are exposed to; and (2) the peripheral route applies when individuals are strongly influenced by the preferences of others during information assessment. When individuals take the central route their ability to perceive and integrate different dimensions may be supported by an effective presentation of the ideas via the user interface. When individuals take the peripheral route, their information processing may be supported by an effective presentation of preferences of others (for instance, through prioritization of the ideas that are displayed). For individuals who take the peripheral route, prioritization thus influences the evaluation of shared ideas and the tendency to use those ideas in integration.

In the second phase of idea integration, integration among the perceived dimensions occurs, whereby the IS user interface can again play an important role to foster individuals' disposition and motivation. Only if individuals perceive value in idea integration will they become motivated to take the necessary

steps for performing idea integration. The substantial research literature on idea sharing and empirical studies on idea integration provide suggestions on how to motivate information sharing and integration in groups. Examples include the relay method to promote idea elaboration (de Vreede et al., 2000, 2010), and the use of pro-diversity beliefs to elicit more information elaboration, which can lead to information integration (Hom et al., 2007).

We are unaware of previous research studies that have explored the potential of IS user interface features to augment idea integration, but previous research has used display variations when implementing different forms of social comparison (Shepherd et al., 1996). To augment motivation for attending to the shared ideas, any signal of usefulness, legitimacy, or relevance of the ideas could be effective (Sussman & Siegal, 2003). And because the amount of attention allocated to the ideas of others is consistent with the cognitive effort allocated to finding associations among them, higher levels of attention are expected to lead to actuating more idea integration (Simon, 1947). Our attention-based view examines features of the user interface that influence an individual's ability and motivation for performing idea integration through managing the underpinning attention-based processes.

4. Attention-Based View of User Interface Effect on Idea Integration

At the heart of our attention-based view is the assumption that attending to the ideas of others is essential for idea integration and that attention can be managed through the IS user interface. Building on the cognitive network model of creativity and the ability-motivation framework, visibility and prioritization of ideas are used as two interface-based mechanisms (interventions) by which attention to ideas is directed and reinforced (de Vreede et al., 2000; Okhuysen & Eisenhardt, 2002) (Figure 1).

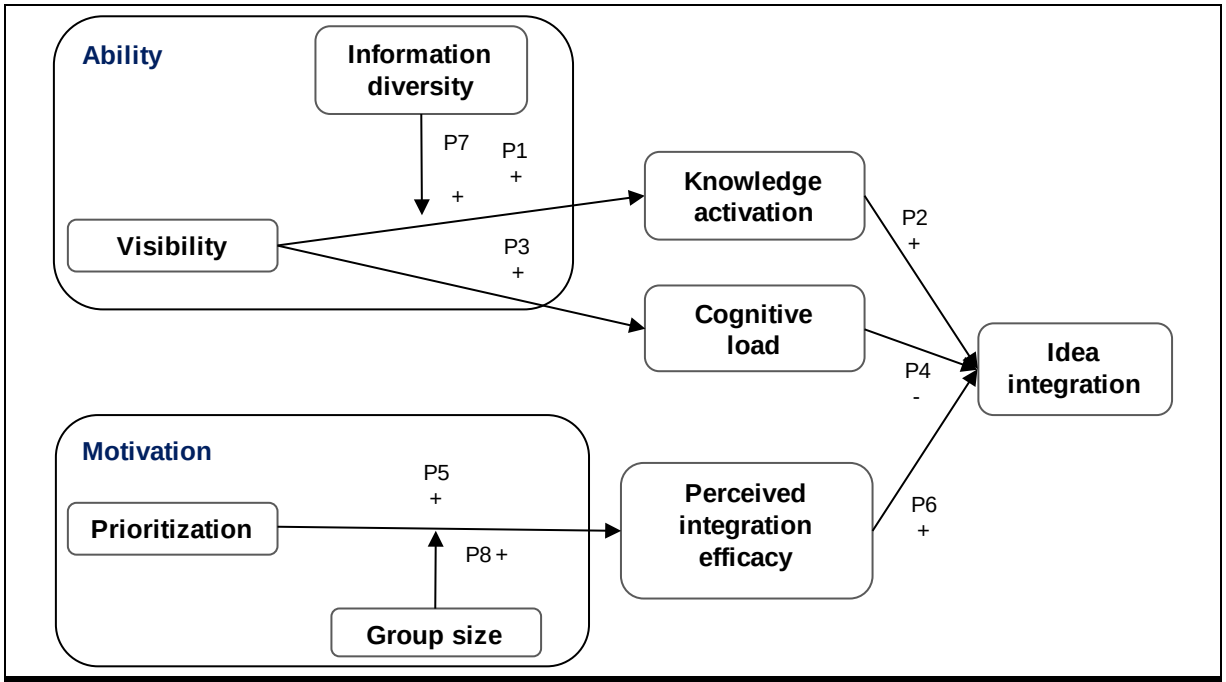

Figure 1. Theoretical Framework

Because individuals can typically focus only on a limited number of ideas at any given time (Simon, 1947), we suggest that only a portion of a larger idea pool will receive effective attention. Thus, ideas generated and shared during brainstorming compete with each other to receive the brainstormers' attention (Hansen & Haas, 2001). To distribute attention among the ideas, chronological order and rank-based order (order based on the collective evaluation of the ideas by the group) are two commonly used methods to organize an idea pool on the screen.

The concept of idea visibility in our model is similar to availability and saliency of issues and answers in existing research studies that apply the attention-based view (Ocasio, 1997; Simon, 1947). Prioritization is also a manifestation of selectiveness by which preferences of individuals are represented through the rating of ideas. Prioritization is proposed to stimulate more idea integration when idea integration is the desirable action. Because individuals are selective in the ideas they attend to and also because the actions that individuals perform – generation, sharing, and integration of ideas – depend on how their attention is channeled, the current attention-based view posits that visibility and prioritization are key drivers of the integrative behavior in EBS (Hollingshead, 1996; Ocasio, 1997). The next section provides the propositions derived from our theory development.

5. Propositions of the Attention-Based View of Idea Integration and User Interface Design

The proposed attention-based view of idea integration posits that individuals must attend to the ideas shared by others to discover new perspectives (integration). According to the cognitive network model of creativity (CNM), attention enables creating connections among different dimensions, which is realized through associations among the corresponding frames in the working memory (Osborn, 1953; Santanen et al., 2004). Taking the ability-motivation framework for directing the attention of individuals in a group context to enhance their ability for idea integration, relative visibility, or salience of ideas becomes important (Dennis, 1996; Santanen et al., 2004). In general, saliency of any chosen mechanism is important for attracting attention and therefore for its effectiveness (Shalley & Oldham, 1997; Shepherd et al., 1996). An empirical study of EBS, for example, used facilitation to increase the saliency of the social comparison technique to mitigate social loafing (Shepherd et al., 1996). As a result, a highly salient social comparison lead to a 63 percent productivity gain compared to only a 22 percent gain for a low salience social comparison.

CNM, however, stipulates that an excessive number of stimuli presented to individuals caused by high saliency or over-exposure to the ideas of others may impede creativity. Thus, idea integration, as a creative process, can be enhanced by selective attention to a limited number of ideas at each point in time. In order to direct the selective attention of an individual, criteria are required to organize ideas on the screen. If the criteria are a proxy of idea usefulness, then the motivation for idea integration is also enhanced (Thoemmes & Conway, 2007). Indeed, any mechanism for inferring usefulness of the shared ideas will augment the individual tendency for using them and therefore will augment motivation (Sussman & Siegal, 2003). We explain visibility and prioritization in Sections 5.1 and 5.2, respectively.

5.1. Visibility

Visibility of ideas that are presented on the screen at any given time in our developed theory can be viewed as an interface-based instance of stimuli quantity per time unit, a CNM construct (Santanen et al., 2004). Visibility of the ideas through the user interface facilitates members' exposure to the different dimensions of the shared ideas and thus stimulates activation of associated frames in working memory. According to CNM (Santanen et al., 2004), the visibility of ideas stimulates search for and retrieval of relevant concepts and thus enables creating connections among those related concepts. Idea visibility is thus a predictor of the idea being used in an integration activity when brainstorming is taking place. With the shift from information scarcity to information richness in modern organizations, visibility of ideas becomes even more important (Hansen & Haas, 2001). Visibility identifies the extent to which ideas generated by members of the group are salient to other members.

While we examine the visibility construct in the current paper in the context of the IS user interface design, it is independent of any particular type of IS technology (Briggs, 2006). We posit that visibility on the screen decreases as the effort for viewing the ideas increases. By visibility, individuals' attention is channeled through the user interface where ideas are presented to them. The extent to which the ideas are exposed to viewers depends on the ideas' position on the screen.

According to CNM, the influence of visibility on idea integration is described by knowledge activation, which is the outcome of searching in long-term memory. Increased visibility leads to an increased number of cues made available by visible ideas, which enhances knowledge activation in memory (Gawronski & Bodenhausen, 2005). The activation of more items in an individual's memory increases the possibility of discovering and articulating connections among the dimensions of different ideas. As pieces of information in visible ideas are more likely to be used as cues to probe an individual's memory, the memory search process is likely to return results that are connected to these ideas; and thus the visible ideas are more likely to be referred to in the integration process. Therefore, we posit that:

Proposition 1: *An increase in visibility leads to an increase in knowledge activation.*

Proposition 2: *An increase in knowledge activation leads to an increase in idea integration.*

Note that even attending to ad-hoc categories and cues provided by others' ideas is beneficial when a problem at hand is unstructured and requires diverse information, which is presumed to be the case in brainstorming. CNM, however, posits that high levels of stimuli presented to individuals also cause an increase in cognitive load (Santanen et al., 2004). Similar experimental studies also found that attending to input from others is detrimental to productivity in brainstorming (Potter & Balthazard, 2004).

When visibility increases, for example, cognitive load and interference have been shown to diminish individuals' ability to discover associations among activated items and thus the ability for idea integration (Potter & Balthazard, 2004; Santanen et al., 2004; van Merrienboer & Sweller, 2005). Also, because the processed ideas and their relevant activated items reside in an intermediate short-term memory that has limited capacity (i.e., memory span), only a few items can be active in memory at the same time. Memory span is defined by the number of elements that one can immediately repeat back, and the general view is that memory has room for about seven elements (Anderson, 2005). Thus, knowledge activation above some threshold may not be possible and therefore would generate no benefit in terms of idea integration. Particularly, CNM scholars have noted that external stimuli contribute to idea generation performance only when delivered at a rate that does not overwhelm the attention and cognitive ability of the brainstormers (Santanen et al., 2004). Considering limited memory span and cognitive interference, the attention-based view developed here suggests that:

Proposition 3: *An increase in idea visibility leads to an increase in cognitive load.*

Proposition 4: *An increase in cognitive load leads to a decrease in idea integration.*

Propositions 1 and 4 suggest that idea integration is curvilinearly associated with visibility through the mediating effect of knowledge activation and cognitive load. The curvilinear nature of this relationship captures cognitive load caused by excessive exposure to inputs from others because reading, understanding, and following the inputs of others will cause cognitive dispersion (Pinsonneault et al., 1999; Potter & Balthazard, 2004). This curvilinear relationship arises from the tradeoff between exposure to ideas of others and attending to those ideas and reflecting on the own background knowledge maps and on creating connections among activated frames (Santanen et al., 2004).

Thus, exposure to ideas of others can at times be beneficial and at times be detrimental depending on its extent (Potter & Balthazard, 2004). While for low levels of visibility, individuals' capacity for retrieving frames from a cognitive map and for creating a connection is not fully utilized, high levels of visibility will cause issues with the capacity limits of working memory, which is the locus for manipulating activated concepts and for discovering new combinations (Santanen et al., 2004). Therefore, our developed theory posits that this curvilinear effect is consistent with the fact that excessive mindfulness will incur costs in terms of the scarce resource of attention (Levinthal & Rerup, 2006). If a high proportion of ideas become visible to the group, they may overwhelm brainstormers, and cause distraction or production blocking (Briggs, 2006; de Vreede et al., 2000).

This tension between combinative creativity (combining already existing ideas) and original creativity (creating new ideas) motivates the current paper's quest for finding an optimal or moderate range of exposure to the ideas of others. Section 5.2 elaborates on prioritization as an instrument for motivating idea integration.

5.2. Prioritization

CNM posits that spreading activation as described in the previous section has automatic and conscious components (Santanen et al., 2004). The automatic part occurs without intention, while the conscious part requires intention and conscious processing. While visibility in our model has a bearing on exposure as an instrument for directing the automatic part of activation, prioritization pertains to the conscious part of activation.

In addition to attending to shared ideas, the conscious aspect of idea integration requires valuing the shared ideas and valuing idea integration. Idea integration in MacGrath's (1984) typology of tasks may be categorized as an intellectual and a cooperative task. For idea integration to occur, it is necessary that individuals in the groups positively evaluate the ideas shared by others (Borgatti & Cross, 2003; Sussman & Siegal, 2003). Because individuals engage in social interaction based on the expectation of some type of rewards, individuals should perceive value in idea integration so that they process shared ideas and then engage in integrating them with their own ideas (Blau, 1964; Siemsen, Balasubramanian, & Roth, 2007).

We define prioritization here by using a criterion or a set of criteria for ordering ideas on the screen. The most commonly used prioritization method in verbal brainstorming is collective evaluation by the group. This collective evaluation is one of the few feasible real-time methods of prioritization in EBS because, during brainstorming, an accurate evaluation of the ideas based on organizational goals (Litchfield, 2008) cannot be accomplished. When there is no prioritization, ideas may be displayed on the screen based on their chronological order or ideas may be shuffled on the screen randomly.

Thus, the criterion for prioritization can be individual preferences regarding the shared ideas as indicated through a rating scale. Using this method, ideas are prioritized if they are ordered based on the collective ratings by the group. Prioritization based on the collective rating is analogous to the use of citation numbers in academic paper databases to infer the influence of research papers. Many state-of-the-art online discussion platforms use similar mechanisms, such as star rating systems (used in Amazon.com reviews or in Yahoo Answers). Similarly, file, music, and video sharing and many online newspapers and news aggregators provide individuals with a mechanism to evaluate items and then use the aggregated ratings as a criterion to determine visibility of the items. In EBS, when the number of visible ideas on the screen is limited, lower-ranked ideas will be placed down the list. As a result, the probability of an idea being exposed to individuals' attention is high for high-priority ideas, and low for low-priority ideas.

Following the ability-motivation framework, the current paper introduces the perceived integration efficacy construct to capture an individual's evaluation of others' ideas and the individual's proclivity to idea integration. Perceived integration efficacy is defined to encompass (1) the perceived value of information, as the evaluation of others' ideas by an individual; and (2) the perceived value of integration, as the perception of the gains from idea integration. We posit that the criterion for ordering ideas influences perceived integration efficacy. For instance, if the ideas are prioritized based on the group's collective evaluation, individuals tend to attribute more value to the ideas being displayed. Moreover, prioritization reduces uncertainty in individual decision making for idea integration. Thus, we submit that individual perception of the integration efficacy is higher when ideas are prioritized by the group, and this logic leads to the following proposition:

> ***Proposition 5:*** *An increase in prioritization leads to an increase in perceived integration efficacy.*

In summary, based on the ability-motivation framework, Proposition 5 states that prioritization of ideas on the screen will provide individuals with easy access to the preferences of others and consequently influence their motivation for idea integration, which is represented through perceived integration efficacy in our developed theory. The discussion of how accurately a particular prioritization method represents the actual values of the ideas or whether prioritization criteria are moderately or significantly discounted by individuals when selecting ideas for integration is beyond the scope of the current paper. Instead, our theory posits that the mere presence of a prioritization mechanism will enhance the total amount of attention allocated to the shared ideas and increase the extent to which they are reviewed and considered.

5.3. Perceived Integration Efficacy

Because individuals differ in the extent to which they value diversity, prioritization provides a feasible (albeit imperfect) mechanism for promoting the tendency of an individual to integrate by increasing the perceived integration efficacy (Petty & Cacioppo, 1986). In our developed theory, perceived integration efficacy is defined by two sub-constructs. The first sub-construct relates to the belief of an individual regarding the value of the shared ideas (perceived value of ideas), which is similar to information usefulness (Sussman & Siegal, 2003) but is more general than perceived information credibility (Dennis, 1996), and has been used in prior research studies of information adoption and use. The second sub-construct relates to the perceived value of idea integration; that is, an individual's belief regarding the extent to which integration contributes to the value of the ideas generated by the individual, and is a new concept introduced in the current paper.

According to the ability-motivation framework, we posit that higher levels of perceived value of idea integration will elicit more idea integration because individuals tend to base their actions on the believed consequences of those actions (Simon, 1947). The extant literature on information adoption and use also suggests that perceived usefulness, credibility, or value of the knowledge item will trigger its use and adoption (Sussman & Siegal, 2003). Thus, the current paper posits that individuals are more likely to integrate ideas when perceived integration efficacy is high:

> ***Proposition 6:*** *An increase in perceived integration efficacy leads to an increase in idea integration.*

Perceived integrative efficacy is expected to be a formative construct that includes the perceived value of ideas and the perceived value of idea integration (Edwards & Bagozzi, 2000). Each sub-construct may be represented by a set of reflective items. Section 5.4 considers two important moderators of the current paper's framework.

5.4. Moderators

The substantial research literature on brainstorming and electronic brainstorming has identified a variety of factors that influence the quality of the brainstorming process. Some examples are group nominal and logical size, group composition, group leadership, members' engagement, facilitation and facilitation saliency, time structuring, and evaluation mechanisms (de Vreede et al., 2003; Fjermestad & Hiltz, 2001; Santanen et al., 2004; Valacich, Wheeler, Mennecke, & Wachter, 1995; Zhou & Shalley, 2007). It is naturally expected that the relationship between the IS user interface and idea integration will be impacted by some of these elements. CNM, for instance, posits that the diversity of stimuli presented to individuals increases the associative distance among the activated frames in the working memory and thus augments creativity. Because the diversity of stimuli that are presented to individuals in EBS is represented by the extent of information diversity of visible ideas, information diversity is proposed to be a key moderator in our model. Also, group size, which has proven to be a critical moderator in the study of group brainstorming (Dennis & Wixom, 2001; Gallupe et al., 1992), is proposed to influence prioritization effectiveness. We describe the moderating effects of information diversity and group size on the associations between visibility and knowledge activation, and between prioritization and perceived integration efficacy respectively, in the Sections 5.4.1 and 5.4.2, respectively.

5.4.1. Information Diversity

As ideas that are attended to become more diverse, the potential for integration increases because information diversity will by itself stimulate integration (van Knippenberg, De Dreu, & Homan, 2004). Information diversity here represents the variety of ideas or more precisely the variety of information contained in the ideas that are generated and shared by individuals in the group. This type of diversity has been linked to higher levels of creativity and complex thinking (Harrison & Klein, 2007). Information diversity results in diversity of stimuli, which draws higher levels of disparity among concepts that are retrieved from long-term memory (Santanen et al., 2004). The higher the disparity among activated concepts in working memory, the higher the potential for idea integration. If knowledge that is possessed and shared by individuals is homogenous or identical, there will be no gain from integration (Grant, 1996a). Because integration occurs when different perspectives are combined, *ceteris paribus*, a highly diverse set of visible ideas is more likely to stimulate the generation of integrative ideas than a less diverse set of visible ideas. A diverse set of visible ideas contains a diverse set of cues, which may be used for probing memory and thus facilitates retrieval and activation of associatively distant concepts (Santanen et al., 2004). Diversity of ideas, therefore, increases the extent to which visibility influences knowledge activation and idea integration. Thus, the gains from controlled visibility should increase with a higher diversity in the idea pool. Therefore, we suggest that diversity moderates the relationship between visibility and knowledge activation:

> ***Proposition 7:*** *Information diversity moderates the relationship between visibility and knowledge activation, such that an increase in the level of information diversity leads to a stronger association between visibility and knowledge activation.*

While visibility helps with directing individuals' attention and facilitates the activation of relevant concepts, information diversity boosts the disparity among the activated concepts. Moreover, diverse information stimulates original ideas through expanding the logical size of a group (Valacich et al., 1995). Note that empirical research studies have found that the mere presence of diverse information may not provide any benefits for the generation, sharing, or integration of ideas (Phillips, Mannix, Neale, & Gruenfeld, 2004; Woolley, Gerbasi, Chabris, Kosslyn, & Hackman, 2008), unless individuals are motivated to do so. To address the motivation issue, the proposed theory includes both visibility as an enabling force and prioritization as a motivational force for enhancing idea integration.

5.4.2. Group Size

Similar to many theoretical and empirical studies of electronic brainstorming (Dennis & Valacich, 1999; Dennis & Wixom, 2001), group size is considered to be an important moderator of the relationships proposed in the current paper. Particularly, the size of the group is posited to moderate the association between prioritization and perceived integration efficacy. Given that in larger groups more people are available to evaluate an idea (Gallupe et al., 1992), prioritization based on the collective evaluation of the idea will be more credible than it is in smaller groups. Assuming that individuals take the peripheral route for information processing (Petty & Cacioppo, 1986) the extent to which the preferences of others are discounted is expected to be less when the group is larger. Thus, there will be more gain in terms of perceived integration efficacy. Because the idea pool is generally expected to be larger for larger groups, prioritization can have a more intense effect on the ordering of ideas in larger groups, where there is a wider range of positions on the list of ideas, than in smaller groups. Therefore, group size is an important moderator in the model:

> ***Proposition 8:*** *Group size moderates the relationship between prioritization and perceived integration efficacy such that an increase in group size leads to a stronger association between prioritization and perceived integration efficiency.*

Now that the discussion of the proposed theory's constructs and moderators has concluded, a brief guideline for conducting empirical examination of our developed theory follows.

6. Experimental Examinations of the Theory

The proposed theory could be examined in both laboratory and field settings. In laboratory experiments, hypotheses derived from the propositions of the theory may be tested in experiments with the following factorial design: three (visibility low, medium, and high) by two (prioritization, no prioritization) by two (small groups, large group). Participants in the lab experiments would be invited to brainstorm electronically in groups using an experimental software system that allows for manipulations of visibility and prioritization. The task can be an open idea-generation task.

Visibility could be manipulated by varying the number of ideas that are displayed on the screen, and prioritization could be implemented as star ratings provided by the brainstormers. To motivate brainstormers' active participation during the experiment, each participant could be assigned a score that increases for activities that contribute to the group discussion, which include posting an idea, rating other participants' ideas, and referring to other participants' ideas. The individual scores then could be used to determine the likelihood of participants' winning a prize.

The software would generate experimental transcripts to be used for measuring idea integration and information diversity. External coders blind to the experimental conditions should be recruited and trained to analyze the transcripts of the experimental sessions, coding each statement as idea generation or integration (Baker-Brown et al., 1992; de Vreede et al., 2000). Idea generation measurement could be based on the vast IS literature (e.g., Reining et al., 2007), whereas idea integration measurement could be based on the elaboration measure (de Vreede et al., 2000). We anticipate that a multi-level measure of idea integration based on elaboration and integrative complexity measures would best suit the context of the proposed theory (Baker-Brown et al., 1992; de Vreede et al., 2000).

Perceived integration efficacy should be measured by its two sub-constructs: (1) perceived value of information, and (2) perceived value of idea integration. Each sub-construct may be represented by a set of reflective items asked in self-report questionnaires. Perceived value of information, for instance, may be measured by items such as "I am not sure that all the ideas that others contributed had much value", or "I am convinced that all the ideas everyone posted were valuable" (Dennis, 1996). Perceived value of idea integration may be measured using items such as: "Combining my ideas with ideas posted by others created better ideas", or "I am not sure if using ideas posted by others has helped me generate better ideas".

The theoretical construct of prioritization is expected to have distinct effects when examined in small groups *vis-à-vis* large groups (Fjermestad & Hiltz, 1999). The research literature has posited that dyads behave differently than large groups in many ways. In experimental studies of group support systems, the smallest unit has usually been groups of three.

The empirical testing of the theory developed here may also be performed by collecting data from relevant resources available online and across different platforms, such as Yahoo answers, Facebook, discussion forums, Twitter, or similar applications. Empirical research may further examine whether manipulations derived from the propositions of the current theory elicit different forms of effect when used in sequential or parallel settings (de Vreede 2000, 2010; Fjermestad & Hiltz, 2001). Empirical studies may also be designed to examine the propositions in settings where individuals use the IS in several sessions to test for possible effects of adaptive structuration on user interface-idea integration relationships (e.g., Niederman, Briggs, de Vreede, & Kolfschoten, 2008).

7. Contributions

This section summarizes this paper's contributions four areas of scholarship.

(1) Contributions to the electronic brainstorming literature: The conceptualized link between user interface and idea integration, which is built based on the cognitive network model of creativity (Santanen et al., 2004) provides the foundation for the design of EBS with predictable levels of idea integration. Idea integration can increase the number of combinative ideas and therefore can deepen the understanding within groups and can curtail the number of redundant ideas (de Vreede et al., 2000, 2010). Because excessive elaboration may limit the boundary of the solution space, our developed theory of idea integration provides a basis for balancing the original idea generation with idea integration. It also aspires to contribute to the discussion of productivity and effectiveness of EBS (de Vreede et al., 2003, 2010) by advancing idea integration as a key EBS productivity measure (Dennis & Valacich, 1999).

(2) Contributions to the IS literature on user interface design: IS user interface has a high potential for supporting cognitively intensive tasks such as brainstorming. This study extends the use of interface attributes for achieving idea integration and constructs a theory that links IS user interface design to the underpinning attention-based processes for enabling and motivating idea integration (Dennis et al., 1996). The quest for finding a better fit between user interface features and the cognitive requirements of idea integration provides a new pathway for research and practice on IS interface design (Rao, Jacob, & Lin, 1992).

(3) Implications for organizational knowledge integration and use: Building on Simon's (1947) logic for attention as a scarce resource in organizations, the proposed theory links IS interface attributes to the creation of an organization's knowledge-based capabilities. Idea integration and elaboration (de Vreede et al., 2003) are important for ensuring the relevance of EBS to the creation of an organization's knowledge-based capabilities (Grant, 1996b). Therefore, this theory reinforces the role of information technology (IT) in creating organizational knowledge resources, which can rationalize IT investments in organizations.

(4) Implications for practice: With the extensive use of collective content-creation platforms in organizations, we provide a set of decision-making criteria for managers and group leaders to optimally employ the resources of their knowledge workers. For instance, managers are usually faced with the tradeoff between breadth and depth of the ideas that are generated in the groups when exposing individuals to their partners' ideas (de Vreede et al., 2000). While elaboration and idea integration ensure depth in the discussion, it is desirable that breadth is also preserved. Insights from our proposed theory can inform technology choices to achieve the desired level of depth or breadth. Furthermore, empirical studies based on the theory proposed here and its extension may prove to be insightful to managerial decision making on the choice of technological tools for enhanced idea integration performance.

8. Future Research

Although idea generation and sharing provide no benefits to the group and organization unless ideas are integrated and used (Grant, 1996b), the first two tasks are necessary for idea integration in groups. Therefore, the focus of the current theory on idea integration reflects the boundary conditions of the proposed theory. Eventually, a more comprehensive theory of user interface design that addresses all three processes – generation, sharing, and integration – should be developed.

It is also desirable to examine whether the method of prioritization matters. IS research has found that having a basis for social comparison improves productivity but the baseline level does not affect the results (Shepherd et al., 1996). A similar question exists for levels and methods of prioritization to discover whether the form of the prioritization methods induces a significant change in its effect on idea integration.

Also, because information diversity as a key enabler of idea integration is a convoluted upshot of a series of other factors such as members' knowledge repository diversity, time structuring, and social structure of the group, future research studies could aspire to promote diversity through the user interface (Curseu, Schruijer, & Boros, 2007). Moreover, because facilitation has been found to be an effective intervention method for boosting productivity (Shepherd et al., 1996), it is desirable to study the implementation of facilitation mechanisms through user interfaces, which may prove useful in distributed groups.

An advancement of the current theory could be the identification of user interface attributes other than those discussed here and empirical studies of their effect on idea integration within groups. Examples of such attributes include the structure used to present ideas on the screen (several windows instead of one; e.g., Dennis et al., 1996), threading feature, font size (e.g., digg), and color (McNab, 2009).

Moreover, theoretical and empirical studies on how the user interface may be instrumental in reducing several forms of opportunism that occur within brainstorming groups (e.g., free riding, social loafing, and motivation loss) and enhance idea generation, sharing, and integration in groups will be complementary to the current research (Pinsonneault et al., 1999; Shepherd et al., 1996; Zhou & Shalley, 2007). An important IS research area where motivation poses some limitations on the current theory is the study of idea integration in groups and teams where traditional incentive mechanisms are not present. Additionally, a wide range of individual and social structure characteristics typically influence individual idea integration behavior (Gruenfeld, Mannix, Williams, & Neale, 1996; Rulke & Galaskiewicz, 2000), and we expect that an examination of individual-specific characteristics will advance theory building in this area.

9. Summary and Conclusions

The attention-based view developed here is based on the fundamental logic of Simon (1947) and the concept of bounded rationality, which stems from individuals' limited capacity for attention. We submit that the IS user interface can be instrumental in deploying attention-based interventions. The proposed theory also builds upon the cognitive network model of creativity (Santanen et al., 2004) and the ability-motivation framework (Suedfeld et al., 1992; Thoemmes & Conway, 2007) to link the user interface with human cognition for enabling and motivating individuals to generate integrative ideas. The logical development of this link is a significant achievement for IS research, which has important implications for both IS research and the broader field of organization science.

The proposed theory could inform the design of IS user interfaces for facilitating idea integration by delineating the processes through which visibility and prioritization influence idea integration. The theory developed here subscribes to the IS research quest for improving EBS design, productivity, and efficiency through enhancing idea integration in an era when the speed of idea generation and sharing is sharply surpassing that of idea integration. Practitioners are thus counseled to carefully craft and choose the user interface features to foster idea integration when desired.

The current paper also links the IS user interface to the creation of organizational knowledge-based capabilities through facilitating idea integration within groups. Managing cognitive processes that underpin idea integration through IS can therefore contribute to the sustained competitiveness of organizations.

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