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Are Shared Ideas Used? An Empirical Examination of the Effects of IS User Interface Features on Idea Integration in Electronic Brainstorming

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ABSTRACT

Are shared ideas used? Despite the pervasive use of electronic media for idea generation and idea sharing, the extent and quality of idea integration and use in electronic brainstorming is relatively understudied. This study empirically examines an attention-based theory of idea integration that underscores the importance of IS user interface design. Building upon Cognitive Network Model of Creativity (CNM) and ability-motivation framework, the attention-based view of idea integration formulates a causal model for idea integration in the context of user interface. The causal model focuses on the effect of idea visibility and prioritization on idea integration and the extent to which those relationships are moderated by information diversity and group size. A full description of the experimental study and its implications are provided in the paper.

Keywords
Idea integration, idea visibility, prioritization, communicative idea integration, elaborative idea integration

INTRODUCTION

The brainstorming process involves generation, sharing, and integration of ideas. In the IS literature, idea integration has been conceptualized as the explicit reference to partners' ideas in the form of comments, and has usually been categorized as a measure of communication within the category of effectiveness measures (Fjermestad & Hiltz 1999, 2001). EBS studies have referred to the task-relevant reference to previously generated ideas as elaboration and have included the concept in productivity measurement (Vreede et al. 2000, 2010). Extant empirical studies on idea integration have indicated that integration does not occur automatically (Homan et al. 2007). Individuals must be able and motivated to integrate ideas (Santanen et al. 2004). Therefore, the IS user interface becomes central to facilitating idea integration and thus to enhancing group brainstorming productivity. Taking a multi-level perspective that is consistent with prior literature on idea integration, the empirical study presented in this paper presents two models for examining the impact of user interface design on communicative and elaborative idea integration.

THEORY AND RESEARCH MODEL

This experimental research examines an attention-based view of user interface influence on idea integration (Javadi et al. 2013; Simon 1947; Ocasio 1997). The attention-based theory of idea integration which builds upon Cognitive Network Model (CNM) of creativity (Santannen et al. 2004) and ability and motivation framework (Thoemmes & Conway 2007) states that attending to others' ideas is essential for idea integration and that attention can be managed through user interface (Simon 1947; March & Simon, 1958). Hypotheses derived from this theory are explained in the next subsections.

Visibility of ideas in the attention-based theory of idea integration is an interface-based instance of the construct stimuli quantity per time unit in the cognitive network model of creativity (Santanen et al. 2004). Visibility defines the extent of information that is presented on the screen at any given time. According to CNM (Santanen et al. 2004), visibility of ideas stimulates search for and retrieval of relevant concepts and thus enables creating connections among those related concepts. Therefore:

Hypothesis 1: An increase in idea visibility leads to an increase in idea integration.

Because integration occurs when different perspectives are combined, ceteris paribus, a highly diverse set of visible ideas is more likely to stimulate generation of integrative ideas than a less diverse set of visible ideas. Thus, the gains from controlled visibility should increase with higher diversity of the idea pool. Therefore we hypothesize that diversity moderates the relationship between visibility and knowledge activation:

Hypothesis 2: Information diversity moderates the relationship between idea visibility and idea integration in that the influence of idea visibility on idea integration is stronger for higher levels of information diversity.

Prioritization based on the collective evaluation of the group is one of the few feasible real-time methods of prioritization in EBS because during brainstorming accurate evaluation of the ideas based on organizational goals (Litchfield 2008) cannot be accomplished. To capture an individual's evaluation of others' ideas and an

individual's proclivity to idea integration, the attention-based theory of idea integration has introduced perceived integration efficacy construct (Javadi et al. 2013). Perceived integration efficacy is defined to encompass (1) individuals' evaluation of others' ideas (perceived value of information); and (2) perception of the gains from idea integration (perceived value of integration). It is then posited that prioritization influences an individual's perceived integration efficacy. If the ideas are prioritized based on the group's collective evaluation, individuals attribute more value to the ideas being displayed. Moreover, prioritization reduces uncertainty in individual decision making for idea integration. It is thus proposed that:

Hypothesis 3: Prioritization leads to formation of higher levels of perceived value of information.

Hypothesis 4: Prioritization leads to formation of higher levels of perceived value of idea integration.

Perceived value of information is similar to information usefulness (Sussman & Siegal 2003) but is more general than perceived information credibility (Dennis 1996), which have been used in prior research studies of information adoption and use. The attention-based theory of idea integration posits that higher levels of perceived value of idea integration will elicit more idea integration, because individuals' actions are generally based upon their beliefs of the consequences of those actions (Simon 1976). Perceived value of information also, has been proven to augment idea use. For instance, the extant literature on information adoption and use suggests that perceived usefulness or credibility or value of the knowledge item will trigger its use and adoption (Sussman & Siegal, 2003), therefore:

Hypotheses 5: An increase in perceived value of information leads to an increase in idea integration.

Hypotheses 6: An increase in perceived value of idea integration leads to an increase in idea integration.

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. Moreover, since in general the idea pool is expected to be larger for larger groups, prioritization has more of an intense effect on ordering ideas in larger groups (wider range of positions on the list of ideas) than it has in smaller groups. As such, group size is an important moderator in the *model:*

Hypotheses 7: Group size moderates the relationship between prioritization and perceived value of information in that the positive effect of prioritization on perceived value of information is stronger for larger groups.

Hypotheses 8: Group size moderates the relationship between prioritization and perceived value of idea integration in that the effect of prioritization on perceived value of idea integration is stronger for larger groups.

Here we conclude the discussion of the hypotheses derived from the attention-based view of idea integration and continue to report of our experimental study in the following section.

METHOD

The hypotheses described in the previous section were examined in a laboratory setting with groups brainstorming on a desert survival problem (Homan *et al.*, 2007). The experiment had a 2 * 2 * 2 factorial design (visibility: low, high; prioritization: yes, no; group size: small, large) and participants were randomly assigned to experimental conditions. Participants in each experimental session discussed electronically within groups using an experimental software system that allowed for manipulations of visibility and prioritization. More details of the experimental design are described in the following sections. Participants were recruited from two upper-level business courses at a large Mid-Western university in the United States and participated in exchange for extra credit; also with a chance to win a lottery. Participants were randomly assigned to different experimental conditions and all participants in a particular session participated in the same condition. Two external coders who were blind to the experimental conditions were asked to code transcripts of the experimental sessions. The coders were asked to first read an entire transcript to understand the flow of discussions within groups. The coders then were asked to read each statement that was exchanged by individuals and code them as idea generation or integration, as shown in Table 3 and Table 4. An idea in this paper was defined as a statement that consists of at least one testable proposition (Simon 1947; deVreede *et al.* 2003). Idea dimensions, which are building blocks of idea integration, are defined as "unique testable propositions. Examples of one-dimensional and multi-dimensional ideas, value statement, and mere descriptions of facts are included in Table 1.

Table 1. Statements and Ideas

Description	Example from Experimental Sessions
One-dimensional idea	I think some sort of tarp would be useful for shade and shelter
Multi-dimensional idea	Some sort of outer shell jacket that is water proof, can be used to collect water if it rains, covers body at night
Mere description of facts (not counted as an idea)	-What about the money we have, we each have 2.83 in change...plus $85 in bills -Well we are 65 miles off course and we know we are in and S - SW of the mining camp
Value Statement (not counted as an idea)	We have to stick together though.

To measure idea integration, the external coders were asked to read statements on the experimental transcripts and complete a row in the coding table with the following

information: # of unique new items is the item justified? (Are reasons included), classification to communicative idea integration or elaborative idea integration, or other. Table 2 contains examples for the above categories.

Table 2: Coding Different Levels of Idea Integration

Description/Definition	Example from Experimental Sessions
Communicative Idea Integration	
Challenge without reason: challenge of, query to someone else's idea without providing any reason	P1: Take a cooler P2: why?
Approve without additional reason: approving somebody else's idea without providing any additional reason/justification.	P1: maybe some kind of solar powered flashlight to use with the compass for nighttime travel P2: I think the flashlight idea is good
Elaborative Idea Integration	
Type 1:	
Challenge with reason: challenge of, query to someone else's idea: with reason but without providing alternatives.	P1: Medical first aid kit from plan P2: but they said we weren't hurt
Approve with reason: approving somebody else's idea and providing additional reason/justification.	P1: I think in the middle of nowhere map might be better P2: yes, especially if we are in a zone with no reception
Type 2:	
Alternative: alternative to or improvement of an existing idea.	P1: How about a flashlight for when it gets dark? P2: maybe some kind of solar powered flashlight to use with the compass for nighttime travel

Perceived integration efficacy is measured through measuring its two sub-constructs; *perceived value of information* and *perceived value of idea integration*. Each of the two sub-constructs is measured by four 7-point Likert scale post-experiment questionnaire items which are explained next.

Perceived Value of Information (Dennis 1996) is measured by the following four questions: (1) *I am not sure that all the ideas that others contributed had much value.* (2) *Some people did not post valuable ideas.* (3) *I am not sure I completely attributed value to every idea that was posted by others.* (4) *I am convinced that all the ideas everyone posted was valuable.* Perceived Value of Idea Integration – a new construct introduced in this study - is measured by the following four items: (1) C*ombining my ideas with ideas posted by others created better ideas.* (2) *I am not sure if using ideas posted by others has helped me generate better ideas.* (3) *I am convinced if I use ideas posted by other people I can create better ideas.* (4) *Using other peoples' ideas has not helped me create better ideas.*

The reliability analysis for the measurement items for *perceived value of information* and *perceived value of knowledge integration* was performed for 11 groups in pilot tests with the Cronbach's alpha being 0.761 for the first and 0.68 for the latter.

Because the focus in this paper is on measuring diversity of the cues presented to individuals, we measure information diversity using latent semantic analysis (LSA) method (Landauer *et al.* 1998). For each experimental session we computed LSA measure between any two posts using the system available at *http://lsa.colorado.edu/*. LSA numbers which represent similarity are then converted to represent diversity. The average of all $\frac{n(n-1)}{2}$ binary LSA measures in an experimental session was used as information diversity measure for that session.

STRUCTURAL EQUATION MODEL

To test the structural model and the measurement model the data collected from the experimental sessions were analyzed using the structural equation modeling (SEM). PLS is particularly chosen to test our research model because it is well suited for exploratory research and theory development (in contrast to theory testing with LISREL for example). Our empirical model is illustrated in Figure 2. Communication and elaborative idea integration are treated as two separate constructs. Model fit statistics numbers are available in Table 3.

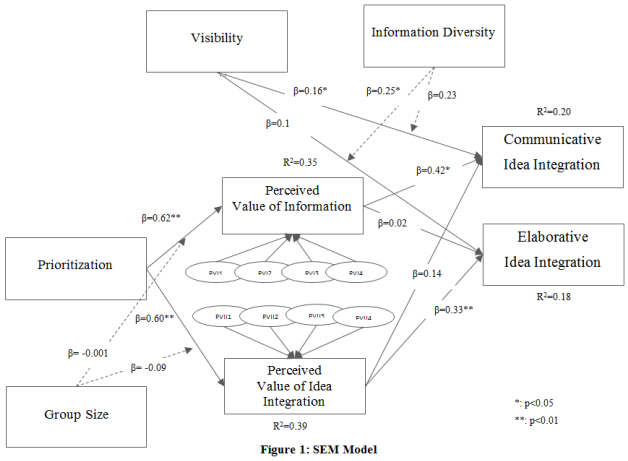

Figure 1: SEM Model

Table 3 : Fit Statistics

Average Path Coefficient (APC)	0.247 P<0.001
Average R-Squared (ARS)	0.281 P=0.003
Average Variance Inflation Factor (AVIF)	1.124 (good if <5)

The loadings of the measurement items for both perceived value of information and perceived value of idea integration are available in Table 4. The factor loadings as

depicted in Table 5 are all above the recommended threshold of 0.5 (p<.001) (Hair, Anderson, & Tatham 1987). The reliability analysis showed that Cronbach's alpha was 0.861 for perceived value of information and was 0.898 for perceived value of idea integration (Number of cases: 226). The Cronbach's alpha values for both constructs are above the recommended threshold of 0.7 (Fornell & Larcker 1981).

Table 4 : Factor Loadings

Perceived Value of Information (PVI)		Perceived Value of Idea Integration (PVII)	
PVI1	0.822	PVII1	0.917
PVI2	0.911	PVII2	0.883
PVI3	0.796	PVII3	0.826
PVI4	0.830	PVII4	0.873

SEM results for Hypotheses 1&2 indicated a distinction between communicative and elaborative idea integration with respect to the effect of idea visibility and information diversity on them. Similarly, the path coefficients for the link between prioritization and perceived value of information (β=0.62, ρ<0.01) and perceived value of idea integration (β=0.60, ρ<0.01) were both significant. Thus as found previously, the experimental data is fully consistent with the relationships formulated in Hypotheses 3&4.

This paper's data is consistent with Hypothesis 5 for communicative idea integration. The data, however, does not provide any information for corroborating Hypothesis 5 for elaborative idea integration. The data is also consistent with the proposed relationships in Hypothesis 6 for communicative idea integration but does not provide any information for corroborating Hypothesis 6 for elaborative idea integration. The moderating effect of group size on the link between perceived value of information and perceived value of idea integration is not observed in our data (β=-.001; β=-0.09) and both path coefficients are non-significant. was conducted in this paper.

DISCUSSION

The SEM analysis has yielded some unexpected yet interesting results. For example, based on the current experimental study, no evidence is available to corroborate that higher idea visibility will lead to an increase in elaborative idea integration.

SEM analysis also revealed the moderating effect for information diversity was only present for the link between idea visibility and elaborative idea integration. The different forms of the relationship between idea visibility communicative and elaborative idea integration can inform future research on idea integration. The SEM analysis also indicated that interaction term, idea visibility* information diversity was a significant predictor for elaborative idea integration but not for communicative idea integration. This finding will guide the rate by which new and diverse ideas are presented to the brainstormers. For instance, when examining the effect of stimuli rate on the extent of creativity in groups (Santanen *et al.* 2004), the frequency and rate at which cues will be presented to the brainstormers may be tailored via the user interface to better fit the form of idea integration that is desired for particular brainstorming contexts. The SEM analysis showed that the indirect link between prioritization and communicative and elaborative idea integration takes two distinct forms. Consistent with our research model (Figure 1), the effect of prioritization on communicative idea integration was realized through the mediating effect of perceived value of information. However, contrary to our theory's prediction, the mediating effect of perceived value of idea integration was not significant for the indirect link between prioritization and communicative idea integration. These findings suggest that regardless of individuals' perception of how idea integration may help them generate better ideas, they will engage in the communicative idea integration provided that individuals value the information contained in other peoples' ideas. The relationship between the perceived value of information and communicative idea integration is represented in the following diagram. As part of WarpPLS algorithm, both variables were normalized.

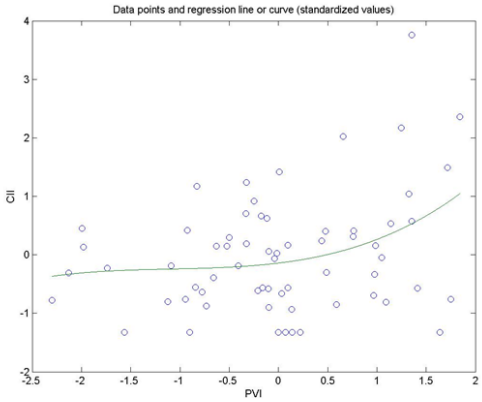

Figure 2: Functional Form between Perceived Value of Information (PVI) and Communicative Idea Integration (CII)

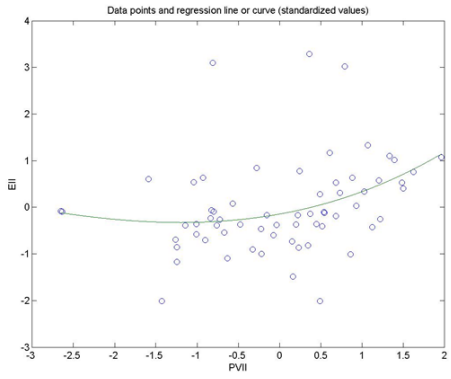

Figure 3: Functional Form between Perceived Value of Idea Integration (PVII) and Elaborative Idea Integration (EI)

The non-linear functional forms depicted in Figure 2 and Figure 3 highlight a relatively more critical role that perceived value of information and perceived value of idea integration play in enhancing idea integration. The above distinct effects implies that perceiving value in others peoples' idea may trigger individuals' tendencies to refer, acknowledge or criticize those ideas but unless individuals perceive value in idea integration, they are not likely to take necessary steps to complement or fully contradict those ideas by providing reasons of their own or by improving those ideas. Examining the effect of prioritization as it pertains to user interface design, we conclude that distinct features can be built into the system for augmenting the perceived value of information or perceived value of idea integration. While we did not find any significant difference between the extent to which prioritization influenced either of the constructs, we anticipate that knowing the inherent difference between the two sub-constructs system designers and user interface experts will be able to craft features that most effectively manage each. At the end, the mixed effect of idea visibility and of prioritization on different levels of idea integration is consistent with one of the core principles of this study that more precise measurement of idea integration construct should be developed. This study's perspective on measuring idea integration should be further verified and enhanced. We also believe that measuring different levels of idea integration will be a critical part of any future studies of idea integration.

Undoubtedly there are imitations to generalizability of the findings of this study posed by controlled experiments with participants from student population. For achieving generalizability, the result of this study should be corroborated in organizational settings where competition and other organizational dynamics influence the process and outcomes of brainstorming. We call for further theoretical and empirical examinations of different forms of idea integration. Since 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 in examining the value created by idea integration (Vreede, *et al*. 2000).

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