To the Faculty of Washington State University:

The members of the Committee appointed to examine the dissertation of JAY J.H. JUNG find it satisfactory and recommend that it be accepted.

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Chair

______________________________
A NEW APPROACH TO ENHANCE GROUP IDEATION:
THE EFFECT OF VERBAL-EBS ON COGNITIVE STIMULATION

Abstract

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Notwithstanding superior performance of electronic brainstorming (EBS) over Nominal and Face-to-Face brainstorming, prior group brainstorming studies point out many remaining crucial process losses (e.g., idea production time underutilization, attention blocking, cognitive inertia, cognitive interference by information overload, and incomplete use of information) that hold back group performance. Thus far, studies have focused on how to improve process gains while neglecting how to mitigate process losses that may be more efficient and effective to enhance group productivity. The proposed research introduced Verbal-EBS that combines the best of both communication modes, speaking and reading, by integrating speech recognition technology with group memory, which is one of the built-ins of existing EBS, and then investigated how to increase the idea production time and the quantity and quality of ideas. A laboratory experiment comparing the performance among Verbal-EBS, Typing-EBS, and Nominal-based EBS was used to test a set of theoretically grounded hypotheses. As prior computer-mediated studies and orality studies in communication suggested that (1) typing is slower than speaking, while reading is faster than listening, and (2) searching for good ideas to build
on is possible with the support of group memory of EBS while speaking but not while writing or typing, individuals who were given Verbal-EBS treatment performed nearly twice as well as individuals with typing treatment. The results enhance our current understanding of group brainstorming that includes how and why Verbal-EBS is theoretically and practically different from traditional Typing-EBS.
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CHAPTER ONE

INTRODUCTION AND RESEARCH PROBLEM

This chapter is composed of three sections. The first section discusses the history of the idea generation performance along with the superiority of Typing-EBS over other means. It then depicts the limitations of the current practice of Typing-EBS, followed by research questions. The second section addresses why this study is important for both research and practice. The third section provides the organization of the dissertation.

1.1 Introduction

In today's fast-paced, knowledge-based economy and society, one's (an individual, a group, or an organization) ability to effectively and efficiently utilize intellectual capital (i.e., information and knowledge) has become critical to obtain and maintain sustained competitive advantages (Cohen & Levinthal, 1990). In particular, the value of creative capacity that exploits the intellectual capital to generate novel ideas to cope with a complex and dynamic environment is undisputable (e.g., Basadur, 1992; Nonaka, 1991). Woodman, Sawyer, and Griffin (1993, p. 293) further argue that “creativity … represents a dramatic aspect of [one's] change that may provide a key to understanding change phenomena and, ultimately, [one's] effectiveness and survival” since change is the essence of creativity.

Despite the importance of creativity, it is often viewed as an abstruse concept or an innate gift inaccessible to the commons. Studies point out one's lack of creativity on account of (1) our society opts for convergent thinking (e.g., judgment based on conformity) rather than divergent thinking (e.g., creativity) (Willings, 1980) and (2) the scantiness of creative education in school. Teaching has been focused too much on rote
learning that is the delivery of information and knowledge without giving individuals instruction in how to use the intellectual capital in creative ways (Luthans, 1995; Osborn, 1957; Parnes, 1967; Schank & Cleary, 1995). For example, a creative ideation competition held by General Foods manifests one's lack of knowledge of the creative process that guides the development of innovative ideas as a result of the underlying reasons discussed above (Hall, 1986).

In order to surmount one's lack of creativity, one frequently turns his or her attention to group meetings or discussions that facilitate an exchange of ideas through communication to forage for new ideas; consequently, most of the important decisions in our society are made by groups, not by single individuals. In other words, the old adage says that "more heads are better than one" or "the whole is greater than the sum of its parts." There seem to be at least two preferred reasons for employing group discussions to seek ideas: (1) groups bring a multiplicity of cognitive resources to the task based on a broad range of skills and experiences of members and combine them into a coordinated performance through social processes (Parks & Sanna, 1999) and (2) cognitive learning perspectives suggest that a higher level of abstract thinking (e.g., metacognition of creativity) is stimulated through a dynamic interaction in a social environment (Bandura, 1986; Piaget, 1970; Vygotsky, 1962, 1978).

To further enhance group creativity for diverse ideation (in terms of efficiency, effectiveness, and satisfaction) by utilizing groups' potential capability (e.g., rich resource conveyance & sharability and error checking) and by overcoming communication
problems\textsuperscript{1} that inevitably occur in group interaction, numerous structured techniques such as Brainstorming (Osborn, 1957), Delphi (Dalkey, 1969), and Nominal Group (Van de Ven & Delbecq, 1971, 1974) have been introduced. Empirical evaluation of these group-based methods has consistently found that non-interacting individuals (i.e., a nominal group) whose ideas are pooled consistently outperform interacting groups (McGrath, 1984). The following quotation by McGrath (1984) provides a succinct summary:

The evidence speaks loud and clear: Individuals working separately generate many more, and more creative (as ranked by judges) ideas than do groups, even when the redundancies among member ideas are deleted, and of course, without the simulation of hearing and piggybacking on the ideas of others.

The difference is large, robust, and general. (p. 131)

Diehl and Stroebe (1987) identified production blocking\textsuperscript{2}, evaluation apprehension, and free riding as explanations for why interacting groups have performed so poorly and concluded that production blocking was the main cause of the poor performance of the interacting groups.

\textsuperscript{1} Studies (Dennis & Valacich, 1993, p. 531; Hill, 1982; Steiner, 1972) agree that "communication introduces factors that increase performance (called process gains) and factors that inhibit performance (called process losses)."

\textsuperscript{2} Production blocking occurs when a group member has the floor. As a result, other members may forget or suppress their ideas (a.k.a. attenuation blocking), concentrate on remembering their ideas (a.k.a. concentration blocking), or constantly listen to others when speaking (a.k.a. attention blocking) (Nunamaker, Dennis, Valacich, Vogel, & George, 1991).
DeSanctis and Poole (1994) note that technology features can play a critical role in the outcomes of group interaction and performance. With the advent of computing and networking technologies, recent researchers in MIS have investigated how computer-mediation could be used to overcome production blocking and other process losses (see Lamm & Trommsdorff, 1973; Nunamaker et al., 1991; Steiner, 1972) by introducing Electronic Brainstorming (EBS). In this computer-based research, studies have found computer-based groups outperform non-supported groups (Gallupe, Dennis, Cooper, Valacich, & Bastianutti, 1992) and larger sized computer-based groups (beyond seven to nine members) outperform nominal groups (Dennis & Valacich, 1993, 1999; Valacich, Dennis, & Connolly, 1994a). For smaller sized groups, few differences between nominal and computer-based groups have been found (Gallupe, Bastianutti, & Cooper, 1991). Valacich et al. (1994a) concluded this line of work as follows:

The EBS group appears to be a superior idea-generating technology for large groups, and no worse than the nominal procedure for small groups. (p. 463)

The outperformance of EBS (in particular, in larger groups) over other means comes mainly from (1) elimination of production blocking and (2) cognitive stimulation from

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3 Cognitive stimulation and social facilitation as major, potential process gains have received the most attention (Dennis & Williams 2003). Although the presence of others has a positive effect (called social facilitation) (Bond & Titus 1983), Paulus and Dzindolet (1993) conclude that in group brainstorming, the effect of others’ presence is not sufficient enough to influence the outcomes. Valacich et al.’s (1994b) finding indicates that physical proximity reduces the performance of computer-mediated groups,
reading the ideas of others, which both are enabled with the support of technology features such as parallelism, group memory, anonymity, etc. These technology features are guided and developed by theoretical underpinnings that endeavor to hurdle human weaknesses in the group ideation process (e.g., the four theoretical counter-mechanisms that structure and support tasks and processes to facilitate process gains and to mitigate process losses (see Nunamaker et al., 1991 for more details)), rather than the technology per se.

Notwithstanding the ability of EBS to outperform as advanced information technology, prior group brainstorming studies mention that there still remain many other types of crucial process losses (e.g., see Table 1.1 below) that hold back the performance of EBS. Although group brainstorming research has reached a saturation point over several decades, these examples clearly indicate an uncharted territory of brainstorming that opens up a new window of opportunity for further investigation. Studies (Pinsonneault, Barki, Gallupe, & Hoppen, 1999, p. 378; Amabile, 1996) suggest that “avoiding or eliminating the process losses that undermine creativity may be more effective in enhancing group productivity than reinforcing the process gains.” Prior studies have focused on how to improve the process gains (e.g., multiple dialogues (Dennis, Valacich, Carte, Garfield, Haley, & Aronson, 1997) and cognitive styles (Garfield, Taylor, Dennis, & Satzinger, 2001)), overlooking how to mitigate the process losses. Thus, among the various factors identified above, this study focuses specifically

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further evidencing less significant effect of social facilitation by others’ presences on EBS performance.
on Gallupe et al.’s (1994) finding that is production time underutilization in an attempt to mitigate process loss and in turn to enhance the performance of EBS. Their experiment shows that regardless of group conditions (electronic or verbal), the average time spent on producing ideas per person is astonishingly only fractions of the total amount of time available (167 seconds for electronic and 98 seconds for verbal out of 900 seconds). This result is consistent with the outcomes of other studies even with increasing group size. (As mentioned, the size of a group affects the degree of cognitive stimulation. Prior studies show the same pattern of production time underutilization). Table 1.2 shows a summary of per-person participation in prior studies.
<table>
<thead>
<tr>
<th>Process losses</th>
<th>Description</th>
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<tbody>
<tr>
<td>Production time underutilization</td>
<td>The tendency of group members to not fully utilize a given time in an idea generation session, regardless of group types (face-to-face, nominal, or electronic) (Gallupe, Cooper, Grisé, &amp; Bastianutti, 1994).</td>
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<tr>
<td>Attention blocking</td>
<td>In a verbal brainstorming group, this occurs when members need to listen to others speak rather than generating new ideas (Diehl &amp; Stroebe, 1987). In an EBS group, parallelism deters group members from attending to other participants’ comments because he or she is busy typing in his or her own comments (Straus, 1996).</td>
</tr>
<tr>
<td>Cognitive inertia</td>
<td>The tendency of group meetings to focus on a few lines of thought, remaining in less divergent deviation (Dennis, Valacich, &amp; Nunamaker, 1990; Dennis, Aronson, Heninger, &amp; Walker, 1999; Lamm &amp; Trommsdorff, 1973).</td>
</tr>
<tr>
<td>Cognitive interference by information overload</td>
<td>Incoming ideas generated through parallelism are too numerous to process, interfering with one's internal idea generation (Lamm &amp; Trommsdorff, 1973; Speier, Valacich, &amp; Vessey, 1999).</td>
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<tr>
<td>Incomplete use of information / biased</td>
<td>The tendency of group members to discuss common information rather than unique information (Parks &amp;</td>
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<td>------------------------</td>
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<tr>
<td>sampling</td>
<td>Sanna, 1999; Stasser, 1992)</td>
</tr>
<tr>
<td>Social comparison and</td>
<td>This phenomenon occurs due to a random group</td>
</tr>
<tr>
<td>matching</td>
<td>composition, which probabilistically includes equal numbers of high performers and low performers.</td>
</tr>
<tr>
<td></td>
<td>In face-to-face groups, members tend to match their productivity to that of the least productive</td>
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<tr>
<td></td>
<td>member (Paulus &amp; Dzindlet, 1993). In EBS groups, the performance regresses toward the mean (Roy,</td>
</tr>
<tr>
<td></td>
<td>Gauvin, Limayem, 1996).</td>
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<tr>
<td>Social or cognitive</td>
<td>The reduction of individual effort in a collective setting</td>
</tr>
<tr>
<td>loafing</td>
<td>(Kerr, 1983; Szymanski &amp; Harkins, 1987; Williams &amp; Karau, 1991). It tends to increase as group size</td>
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<td>Study</td>
<td>Group size</td>
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<tr>
<td>Dennis, Valacich, and Nunamaker (1990)</td>
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<td></td>
<td>7-11</td>
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<td></td>
<td>12 or more</td>
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<tr>
<td>Gallupe, Bastianutti, and Cooper (1991)</td>
<td>4</td>
</tr>
<tr>
<td>Gallupe, Dennis, Cooper, Valacich, Bastianutti, and Nunamaker (1992)</td>
<td>4 (exp 1)</td>
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<tr>
<td></td>
<td>6 (exp 1)</td>
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<td>6 (exp 2)</td>
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<td>12 (exp 2)</td>
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<td>Dennis and Valacich (1993)</td>
<td>6</td>
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<td>Gallupe, Cooper, Grisé, and Bastianutti (1994)</td>
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<td>4 (exp 3)</td>
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<td>Valacich, Dennis, and Connolly (1994)</td>
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<td>9 (exp 1)</td>
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<td>18 (exp 1)</td>
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<td>6 (exp 3)</td>
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<td>12 (exp 3)</td>
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* All studies above reported number of non-redundant ideas. To be conservative, number of unique ideas plus the standard deviation on the plus side for per-person participation was used. The purpose of this measure was to observe a pattern, not a precision.

* 9.5 sec: an estimated production time per idea in EBS (Gallupe et al., 1994).
One plausible explanation for production time underutilization is that members seem to spend the majority of their time (total-time minus production-time) not only incubating ideas (developing or rehearsing new ideas and processing or reprocessing shared ideas) but also idling (Gallupe et al., 1994). Expanding on the above explanation, another plausible explanation is typing ideas. EBS certainly eliminates floor time in face-to-face groups by the parallelism. However, as studies (Dennis et al., 1990; Nunamaker et al., 1991; Williams & Karau, 1991) point out that typing or writing is slower than speaking, the idea generation speed of typing is much slower than talking out\(^4\), which is process loss. This leads to a question that in the process of creative idea generation that prefers quantity of ideas\(^5\), typing that slows down idea presentation may have a reverse effect on efficiency and effectiveness of group ideation.

Thus, this study introduces and explores the potentials of Verbal-EBS that incorporates voice recognition technology into existing Typing-EBS in an attempt to increase the production time and, in turn, to increase the quantity and quality of ideas. The voice recognition will seamlessly dictate as members speak into EBS, will allow spontaneous idea building or piggybacking (i.e., to take an idea of others and expand

\(^4\) Gallupe et al. (1994) report an estimated production time per idea between electronic and verbal: 9.5 seconds for electronic and 6.5 seconds for verbal. Chafe (1982) suggests that typing occurs at around one-third the speed of speaking, not for the creation of new language but for copying. In general, we speak about ten times faster than we can write (Jahanderie, 1999).

\(^5\) "Quantity helps breed quality" (Osborn, 1957, p. 167), meaning that the more ideas, the more the likelihood of getting stimulating ideas.
upon it to yield a synergy), and will increase idea addition and feedback with much less
time delay compared to typing an idea. This suggests the following primary research
question:

**RQ1: Is voice input better for idea entry than typing?**

As delineated earlier, the idea generation performance of individuals and groups
has a long history of investigation. Given the empirical fact that both EBS and nominal
outperform face-to-face, the performance comparison between EBS and nominal is far
from settled. To be specific, the overall empirical evidence (Dennis & Valacich, 1999a;
Roy et al., 1996) suggests that EBS outperforms nominal in larger group sizes (nine or
more), and is no worse than nominal in smaller group sizes. Why is the performance
between EBS and nominal mixed in smaller groups? This is one of the most intriguing
questions that still remain unresolved. In this performance regard in smaller groups,
Paulus, Larey, and Ortega (1995) looked into the effect of idea verbalization using tape
recorders, instead of writing down on paper in nominal groups. They reported that
“electronic brainstorming procedures do not match the output of nominal groups that
respond orally.” (p. 261). This seems to set a new record in the history of idea
generation. However, their result is still inconclusive because they were unable to
compare the performance with that of interacting Verbal-EBS groups due to the
unavailability of technology at that time. Verbal-EBS, which simulates verbal
communication in an electronic communication way and utilizes existing technology
features (e.g., parallelism, anonymity, group memory, and structured group processes) by
combining both speaking and reading that are considered the most ideal type of EBS
(Dennis et al., 1990), may facilitate the flow of idea stimulation and generation better
than nominal groups that responded orally in the experiment by Paulus et al. (1995). As a result, it is expected that Verbal-EBS will provide a new clue to improve idea generation performance. This derives a second research question as follows:

**RQ2: Is voice input better for interacting electronic brainstorming groups?**

Based on the two research questions above, the research model is derived below (see Figure 1). Two group types (nominal and interacting) and two communication media (Typing-EBS and Verbal-EBS) are identified, resulting in four treatments. The performance (in terms of quantity and quality of ideas and satisfaction) among treatments will be investigated.

**Figure 1. Research Model**
1.2 Importance of Research and Practice

1.2.1 Research

Since the inception of brainstorming, it has been theorized that quantity breeds quality (Osborn, 1957; see also Connolly, Jessup, & Valacich, 1990; Diehl & Stroebe, 1987). In other words, a larger pool of ideas, which is more likely to contain more stimulating ideas, is preferred in the process of idea generation. In this regard, communication speed seems to play a crucial role in producing many more ideas. Although parallelism in EBS exploits the notion of quantity to increase communication speed by eliminating the floor time in face-to-face communication, typing certainly does not match the speed of verbal communication in terms of idea production (see Table 2.2 for human interaction speeds). Prior studies (Dennis & Valacich, 1990; Nunamaker et al., 1991; Dennis & Williams, 2003) also point out that slow typing speed reduces the amount of information available. Thus, it is logical to argue that verbalizing instead of typing creates a larger idea pool that likely includes more stimulating ideas. In addition, the literature review (will be discussed in-depth in Chapter Two) shows that typing ideas causes various types of production blocking that were unknown in past studies. Examples include physiological blocking due to a need to key in ideas, cognitive attention blocking to stimuli due to busyness of keying in ideas, psychological blocking because typing ideas is the same as writing, which requires a more serious commitment, etc. To date, no known work has examined the effect of communication speed (i.e., speaking vs. writing or typing) in conjunction with other types of production blocking identified above in the idea generation performance in detail. Given the practical fact (i.e., speaking is faster
than typing), there is a need to theoretically understand the potentials of idea verbalization and to know what extent this can be applicable.

1.2.2 Practice

Despite the recognition and successful utilization of Groupware as a key resource in the workplace, its diffusion into organizations has been slow (Briggs, Nunamaker, & Sprague, 1997/1998). The primary question for this is whether or not computer-mediated groups are noticeably more productive than non-computer-mediated groups. Thus far, “The research is quite clear: With the exception of brainstorming, computer-based groups are not more productive than face-to-face groups” (Parks & Sanna, 1999, p. 176). Despite the high expectation that researchers and practitioners put on EBS (and GDSS in general), evidence demonstrating an overall favorable performance of EBS is marginal in larger groups and mixed in smaller groups when compared to nominal groups (Paulus et al. 1995; Paulus, Larey, & Dzindolet, 2001, Roy et al., 1996). There is certainly no harm in utilizing computer-based groups, but given the cost of setting up and maintaining a computer-based group, the net benefit to the organization is questionable (Parks & Sanna, 1999). Thus, if noticeable increases in productivity are not forthcoming, organizations are suggested not to invest in the Groupware.

Prior studies suggest that communication is a key factor of group creativity because communication process induces factors that either facilitate or inhibit idea generation performance (Dennis & Valacich, 1993; Hill, 1982; Steiner, 1972). This study with Verbal-EBS focuses on how to improve communication speed without losing the benefits of existing Typing-EBS in an effort to increase the productivity noticeably. Also, as pointed out earlier, the value of creativity is a key source to obtain competitive
advantages in today’s economy and society. The nature of idea generation reflects creativity (McGrath, 1984). Thus, identifying and developing a new method or technique has always been our interests, and any means that can improve the idea generation performance can be said to be of a significant practical relevance. Verbal-EBS, which is the most ideal EBS, provides an opportunity to improve communication speed and in turn improve creativity noticeably.

1.3 Structure of the Dissertation

This chapter discussed the general nature of group brainstorming and related methods used, introduced Verbal-EBS to explore its potentials since no such tool exists yet, and outlined the scope of the research. The remaining chapters are organized as follows:

Chapter Two, Theoretical Framework and Research Hypotheses, examines a theoretical importance of Verbal-EBS on intellectual capital conveyance and cognitive stimulation. This chapter is divided into two major sections. Section I provides a review of prior group brainstorming research, including media richness theory (MRT) and media synchronicity theory (MST). Section II reviews orality research in communication and cognitive psychology. This section is further divided into three subsections: speaking vs. typing, reading vs. listening, and integration of speaking and reading, followed by hypotheses.

Chapter Three, Methods, provides a detailed description of how the experiment was conducted. It includes detailed descriptions of operationalization such as research design, interacting group manipulation, idea stimulation manipulation, voice input manipulation, subjects, tasks, and procedures.
Chapter Four, Results, describes the quantitative analysis of the data collected from the experiments and reports the results of the hypotheses.

Chapter Five, Discussion, interprets the results in light of the theoretical framework presented in the study and the specific hypotheses. In addition, it also provides implications for future research and practice.

Chapter Six, Strengths, Limitations, Contributions, and Conclusion, contrasts the strengths and limitations of this study and discusses contributions to the cumulative body of research and practice followed by a summary of the entire study.
CHAPTER TWO

THEORETICAL FRAMEWORK AND RESEARCH HYPOTHESES

This chapter provides literature review related to group psychology, orality in communication, and cognitive psychology that are necessary and sufficient conditions to develop a conceptual framework for this study. This chapter is composed of five subsections. The first section reviews prior group brainstorming studies and derives an argument that speaking electronically conveys a greater amount of information than does typing electronically, mitigating process loss. The second and third sections review literature in orality in communication and cognitive psychology, providing an in-depth analysis of why speaking over writing or typing and reading over listening are theoretically and practically better. Based on this, the fourth section provides a rationale of integrating speaking and reading, which may maximize the productivity of idea generation by stimulating cognition and motivation, two major components of performance, in the context of electronic brainstorming, followed by specific hypotheses to be examined.

2.1 Group Brainstorming Research

The goal of group brainstorming is to generate as many quality ideas as possible. Creative, novel ideas, which are “the patterns of thought” (Blau & McKinley, 1979, p. 200), stem from (1) reorganization of existing facts that seem to have distant associations or even unrelated and irrelevant associations or (2) modification of existing facts in a manner that leads to a perception that the people involved view as new (Anderson, 1992; Van De Ven, 1986). There are mainly three sources for novel or innovative ideas: (1) accumulated internal intellectual capital (Van De Van, 1986), (2) external intellectual
capital: outside sources of the intellectual capital that are borrowed from others (e.g., intellectual stimulation from others) as Cohen and Levinthal (1990, p. 128) point out that “most innovations result from borrowing rather than invention”, and (3) the interaction between internal and external capitals.

To facilitate an exchange of ideas that requires conveyance of meaning in ways that others will understand, group members symbolically communicate through spoken and written words through a variety of communication media (e.g., face-to-face, telephone, letters, etc.). The effect of communication media difference on task performance is well known in the perspective of media richness theory (MRT) (Daft & Lengel, 1986; see also Reder & Conklin, 1987). According to MRT, the degree of a given medium’s richness is determined by its ability to provide immediacy of feedback, multiple nonverbal cues (e.g., facial expressions, gestures, paralanguage), language variety, and the personalization of the medium. Depending on the degree of uncertainty and/or equivocality a given task has, certain media are better able to convey the meaning of information, which leads to the notion of task-media fit. In this notion, face-to-face is the richest medium followed by telephone, personal documents such as letters or memos, impersonal written documents, and numeric documents respectively (see Figure 2.1).

Based on the work of McGrath’s (1984) task circumplex typology that classifies most group tasks into four categories (generating ideas or plans, choosing the correct or a preferred answer, resolving conflicting views or interests, and executing athletic contests and psychomotor tasks) (see Figure 2.2), McGrath and Hollingshead (1993) have applied Daft and Lengel’s (1986) notion to the domain of group decision support systems. They propose task-media fit on information richness (see Figure 2.3). In this framework, tasks
Figure 2.1. Media Richness and Medium of Information Transfer


<table>
<thead>
<tr>
<th>Information Medium</th>
<th>Richness of Information Transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face-to-Face Discussion</td>
<td>Highest</td>
</tr>
<tr>
<td>Telephone Conversations</td>
<td>High</td>
</tr>
<tr>
<td>Informal Letters/ Memos (Personally Addressed)</td>
<td>Moderate</td>
</tr>
<tr>
<td>Formal Written Documents (Impersonally Addressed)</td>
<td>Low</td>
</tr>
<tr>
<td>Formal Numeric Documents</td>
<td>Lowest</td>
</tr>
</tbody>
</table>
Figure 2.2. Task Circumplex Typology

**Figure 2.3. The Task and Media Fit on Information Richness**


<table>
<thead>
<tr>
<th>Task type(s)</th>
<th>Media for Group Communication System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increasing potential richness information</td>
</tr>
<tr>
<td></td>
<td>Computer systems</td>
</tr>
<tr>
<td><strong>Increasing potential richness required For task success</strong></td>
<td>Good fit</td>
</tr>
<tr>
<td><strong>Generating Ideas and plans</strong></td>
<td>Marginal fit Medium too constrained</td>
</tr>
<tr>
<td><strong>Choosing correct answer: Intellective tasks</strong></td>
<td>Poor fit Medium too constrained</td>
</tr>
<tr>
<td><strong>Choosing Preferred answer: Judgment tasks</strong></td>
<td>Poor fit Medium too constrained</td>
</tr>
<tr>
<td><strong>Negotiating conflicts of interests</strong></td>
<td>Poor fit Medium too Constrained</td>
</tr>
</tbody>
</table>
are in an order of the degree of member interdependence and information requirement, and media (computer, audio, video, and face-to-face) are in an order to support member interdependence and information requirement. This framework suggests that the best fit between task and media are on the main diagonal (see Figure 2.3), and “[groups with electronic meeting systems (EMS)] will yield effective task performance if they are doing tasks at or near the generate (low richness) pole of the circumplex” (p. 92). This suggests that idea generation task does not require a rich medium.

Group brainstorming is, indeed, a low equivocal and less interdependent task that (1) does not require an intense interpersonal communication and coordination (Straus and McGrath, 1994; Poole & Jackson, 1993; Trevino, Daft, & Lengel, 1987; Valacich, Paranka, George, & Nunamaker, 1993; Williams, 1977) and (2) lacks social control such as conformity due to the nature of the task that promotes divergent thinking (Jessup & George, 1997). “The redundant paraverbal and nonverbal cues that provide emotional, attitudinal, normative, and other meanings beyond [the transmission of specific ideas] are not needed and in fact may inhibit group performance because of the distraction of communications that are nonessential for effective task performance” (Hollingshead, McGrath, & O’connor, 1993, p. 313 - 314). For example, among three types of production blocking (attenuation, concentration, and attention), members are certainly distracted by listening to the contributions of others. This helps to explain the large, robust finding that typing or writing with no communication (i.e., nominal groups) is more suitable than speaking (i.e., face-to-face groups) in collaborative idea generation.

More recently, Dennis and Valacich (1999b) propose the media synchronicity theory (MST), which expands MRT (1) by pointing out its conceptual and empirical
limitations due mainly to its unaccountability for electronic media (e.g., email, echat, Groupware); and (2) by suggesting an actual fit rather than a perceived fit between task and technology. They propose five media characteristics that can influence communication processes to reduce uncertainty and equivocality: immediacy of feedback, symbol variety, parallelism, rehearsability, and reprocessability. Immediacy of feedback refers to a medium's ability to provide prompt feedback to facilitate shared understanding. Symbol variety encompasses both verbal and nonverbal communications and is the number of ways in which information can be communicated. Parallelism is a medium's ability to process multiple dialogues concurrently. Rehearsability is defined as a medium's ability to give support to carefully edit a message before sending it. Reprocessability is the extent to which a message can be processed again so that it can be reused. By using these five traits to examine a given media's capacity to convey the amount of information (a.k.a. conveyance) and in turn to increase consensus on a shared understanding (a.k.a. convergence), no one medium could be considered the richest (see Table 2.1). MST argues that “pure electronic communication is most suited for tasks in which group members are encouraged to convey information (i.e., generate ideas/alternatives), and possibly explore many divergent possibilities” (Dennis, Wixom, & Vandenberrg, 2001, p. 171) and suggests that "low media synchronicity is preferred for conveyance” (Dennis & Valacich, 1999b, p. 5). This confirms McGrath and Hollingshead’s (1993) view.
Table 2.1. Relative trait salience of selected media


<table>
<thead>
<tr>
<th></th>
<th>Feedback</th>
<th>Symbol Variety</th>
<th>Parallelism</th>
<th>Rehearsability</th>
<th>Reprocessability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face-to-face</td>
<td>high</td>
<td>low-high</td>
<td>low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Video conference</td>
<td>medium-high</td>
<td>low-high</td>
<td>low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Telephone</td>
<td>medium</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low</td>
</tr>
<tr>
<td>Written mail</td>
<td>low</td>
<td>low-medium</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Voice mail</td>
<td>low</td>
<td>low</td>
<td>low</td>
<td>low-medium</td>
<td>high</td>
</tr>
<tr>
<td>Electronic mail</td>
<td>low-medium</td>
<td>low-high</td>
<td>medium</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Electronic phone (&quot;chat&quot;)</td>
<td>medium</td>
<td>low-medium</td>
<td>medium</td>
<td>low-medium</td>
<td>low-medium</td>
</tr>
<tr>
<td>Asynchronous groupware</td>
<td>low</td>
<td>low-high</td>
<td>high</td>
<td>high</td>
<td>high</td>
</tr>
<tr>
<td>Synchronous groupware</td>
<td>low-medium</td>
<td>low-high</td>
<td>high</td>
<td>medium-high</td>
<td>high</td>
</tr>
</tbody>
</table>

In sum, the notion of fit argues that performance depends on fit between task and technology. In this perspective, there is a strong fit between the idea generation task and electronic brainstorming. In his extension of the task-technology framework, Goodhue (1995) further expands the notion of fit by pointing out that the limitation of the task-technology fit approach is a lack of system utilization. Utilization refers to the extent to which users perceive usefulness of systems or intention to use systems and implies that the more utilized the system is, the better the outcomes. Within the context of the current study, EBS combines “positive elements of verbal (members share ideas and build on them) and nominal (members generate ideas with minimal production blocking and evaluation apprehension)” (Dennis & Valacich, 1993, p. 532), demonstrating strong usefulness, which is a determinant of intention to use / utilize (Davis, Bagozzi, & Warshaw, 1989). These theoretical matches (and theoretical mechanisms described in the
introduction section to facilitate cognitive stimulation by reading the ideas of others) lead to the outperformance of EBS in ideation task.

Despite EBS’ superiority over other means, recent studies have clearly made a common suggestion regarding the use of EBS (which uses a keyboard and computer screen to communicate and to exchange ideas) to better motivate cognitive stimulation, in turn increasing the outcomes of group ideation. The followings are excerpts from the literature review:

1. "Certainly one of the most obvious features of the EBS technology is that most group members are busy typing in proposals most of the time” (Valacich et al., 1993, p. 461). However, “typing is slower than speaking, while reading is faster than listening” (Dennis et al., 1990, p. 1051).

2. “Participants typed slower than their verbal counterparts could talk”(Gallupe et al, 1994, p. 82) because “it takes longer to keyboard an idea than to say it” (p. 84), causing some degree of ideation delay.

3. “EBS requires physical demands of typing as opposed to speaking which may yield less in depth discussion and analysis of issues” (Straus & McGrath, 1994, p. 94; Kiesler & Sproull, 1986).

4. “CMC users’ typing requirement reduces the number of messages they are able to transmit in the same period as FtF communicators” (Walther, 1995, p. 189).
5. “Computer-mediated communication would be as efficient as face-to-face communication if group members did not have to type messages” (Siegel, Dubrovsky, Kiesler, & McGuire, 1986, p. 180).

6. “Members who cannot verbalize their ideas immediately may forget or suppress them because they seem less relevant or original later” (Valacich et al., 1994a, p. 451)

Based on the above excerpts, it is speculated that although parallelism, which allows participants to simultaneously type their ideas, mitigates production blocking, it does not completely eliminate production blocking because, by the definition, production blocking occurs when something hinders verbalization of ideas as they occur. In other words, typing as another source of production blocking seems to lead to one of the reasons of production time underutilization. In addition to that, as Dennis and Valacich (1999b, p. 5) suggest “all tasks are composed of two fundamental communication processes, conveyance and convergence.” Prior cumulative studies agree that an electronic channel is the most suitable for information conveyance because electronic channel loses “the redundant paraverbal and nonverbal cues that provide emotional, attitudinal, normative, and other meanings beyond [the transmission of specific ideas] are not needed and in fact may inhibit group performance because of the distraction of communications that are nonessential for effective task performance” (Hollingshead, McGrath, & O’connor, 1993, p. 313 - 314). However, no writing or typing matches speaking in terms of the speed of the amount of information conveyance. Nunamaker et al. (1991) also suggest that the slower speed of typing may induce the lack of information sharing, which is
process loss. Computer-mediated speaking, which is verbal communication in an electronic way enabled by voice recognition technology, can maximize information conveyance and sharing.

In summary of the above suggestions, if participants are freed up from having to type ideas, they may focus more on analytic thoughts and articulation while navigating others' comments. Computer-mediated speaking will also increase attention to important pieces of information because of no need to type, which removes attention blocking (see Straus & McGrath 1994).

2.2 Orality Research

Table 2.2 shows a summary of the findings on typical human interaction speeds for speaking, typing, handwriting, reading, and listening (Bailey, 2000). It shows that typing (or writing) is slower than speaking, while reading is faster than listening. The next subsections will discuss theoretically in depth the differences of each one based on evidence documented in orality research and will derive the integration of speaking and reading that is envisioned to be the most ideal EBS below.
**Table 2.2. Human interaction speeds**


| **Reading** | The average adult reading speed for English prose text in the United States seems to be around 250 to 300 words per minute. When people are proofreading (scanning) text on paper they do so at about 200 words per minute. Performing the exact same task using a monitor, they proofread about 10% slower at 180 words per minute (Ziefle, 1998). |
| **Listening** | People comfortably can hear words that are spoken at from 150 to 160 words per minute. However, listening is more difficult than reading. "Listeners" listen between 25% to 50% of the time. Short-term memory holds 7 +/- 2 items. |
| **Speaking** | People tend to dictate to computers at about 105 (125.0 - 150) words per minute (Karat, Halverson, Horn, and Karat, 1999; Lewis, 1999). |
| **Typing** | Many jobs require keyboard speeds of 60-70 words per minute. However, when actual typing speeds are collected for people that use computers, they are much slower. In one study the typing rates for simple transcription averaged only 33 words per minute, and for composition the average was only 19 words per minute (Karat, Halverson, Horn, and Karat, 1999). |
| **Handwriting** | On average, people write (handprint) at about 31 words per minute for memorized text, and about 22 words per minute when copying text (Brown, 1988). |
2.2.1 Speaking vs. Writing (or Typing)

Just as the computer-mediated group literature points out the performance difference between speaking and typing in idea production, studies in linguistics also suggest differences in the two forms of communication to exchange information and knowledge: Oral and Written, assuming face-to-face conversation as typical speech and informational exposition as typical writing. The differences between these two discourses have a long history of investigation. A series of experimental studies by Horowitz and his colleagues (Horowitz & Berkowitz, 1964; Horowitz & Newman, 1964; Horowitz & Berkowitz, 1967) appear to provide the first formal empirical evidence. In their first study, Horowitz and Newman (1964, p. 640-641) propose six conditions to differentiate spoken and written expression as follows:

1. The usual conditions under which one writes or speaks differ greatly and these conditions alone could assure great differences between the two modes.

2. It is possible that natural or learned proficiency in a mode could affect its production. It is said of a person that “he speaks well” or “he writes easily.” It is probable that when the literature reports that differences are found between these expressive modes no allowance has been made for the possible natural felicity of expression of the speaker or the author.

3. Written language most usually represents more permanent record than spoken language. With such an end the writer would naturally be more deliberate than the speaker. He would make changes in his text until it most nearly conveyed the ideas he wished to express in the manner he
intended to express them. In general, the speaker can take more liberties. He has greater freedom and greater lack of inhibition.

4. Allied to the above is the factor of time for preparation. It is likely that greater deliberateness means more time spent in preparation for a written expression than for a spoken one.

5. Speech is a less effortful mode than writing. Hence, it would tend to be more productive in equal time intervals.

6. Speaking utilizes the “natural” mechanism of the larynx whereas writing (or typing) uses the more labored mechanism of the fingers, wrist, and arm.

In addition to the above six conditions proposed by Horowitz and Newman (1964), there is another critical condition that is the speed of idea production: speaking is faster than typing.

7. We speak about ten times faster than we can write. This speed difference must influence the relationship between our thoughts and our words (Jahandarie, 1999, p. 144). To be specific, “spontaneous spoken language … is produced in spurt … when we speak we are in the habit of moving from one idea to the next at the rate of about one every two seconds. Perhaps that is even our normal ‘thinking rate’, if language reflects the pace of thought. Whether or not this rate applies to all thinking, it is certainty a rate we are accustomed to while we are using language – probably while we are thinking in language to ourselves as well as when we are overtly vocalizing … [In writing], very much of our cognitive
capacity has to be devoted to the mechanical activity of writing itself …
our thoughts must constantly go ahead of our expression of them in a way
to which we are totally unaccustomed when we speak” Chafe (1982, p.
37).

Building on the above propositions, other linguists (e.g., Biber, 1988; Chafe,
1982; Halliday, 1989; Jahandarie, 1999) further refine the differences between the two
modes of communication. Among them, Biber’s (1988) work, which proposes two latent
constructs that differentiate between speaking and writing, seems to be the finest one.
Biber (1988) suggests that the linguistic characteristics of the two modes are functionally
and situationally different. Functional differences are based on four textual dimensions:
integration, fragmentation, involvement, and detachment. Integration refers to the degree
of information density. A typical written sentence is more integrated than is a typical
sentence in speaking because of our educational instruction that “[v]igorous writing is
concise [, smooth, and clear]. A sentence should contain no unnecessary words, a
paragraph no unnecessary sentences” (Strunk & White 2000, on the cover page).
Fragmentation refers to the degree of looseness of sentence structure. A typical sentence
in speech is much more fragmented than is a typical sentence in writing due to natural
spontaneity in interaction, whereas writing, which is entirely artificial (Ong, 1986;
Pinker, 1994), must follow the grammatical information structure. Involvement is a
psychological state, which refers to the degree of interaction between parties. Speaker
and listener can interact with each other, which are “phatic” (Jahandarie, 1999, p. 139),
whereas writer and reader typically cannot do so. Speakers tend to talk in an active voice
about their feelings and feel more involvement with the reality of here and now, making more references to actions and events (Jahandarie, 1999). Detachment refers to the characteristics of writing due to a lack of interaction between writer and reader. “Speaking is a social activity whereas writing is solitary” (Jahandarie, 1999, p. 139).

Situational differences include: (1) physical channel. Speaking uses the auditory channel while writing uses the visual channel. Speaking can utilize multiple channels such as facial expressions, gestures, paralanguage, etc, whereas writing relies on the lexical/syntactic channel. “This difference causes writing to be more linearly explicit than speech, since the information structure of written texts must be marked entirely in the grammatical channel, whereas spoken texts can utilize several channels” (Biber, 1988, p. 38); (2) immediacy of feedback availability. In speech, feedback is immediate. But, in writing, readers cannot provide direct feedback to the writer; (3) degree of permanence. The spoken word is transient. It quickly disappears as soon as it is verbalized. On the other hand, written words are preserved on the paper. Its higher preservability gives writing a feeling of relative permanence that is absent from speech; and (4) purpose. Writing is typically used to present information, whereas speaking is typically used not only to establish interpersonal relationship but also to convey and share information.

In summary of a comparison between speaking and writing, (1) speaking and writing use different biological mechanisms: the natural mechanism of the larynx vs. the learned mechanism of the fingers, wrist, and arm. Speaking is much easier and faster than writing; (2) sentence complexity of writing is higher than in speaking because writers

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Biber (1988) outlines sixteen situational parameters. Many parameters are not highly relevant to this study.
have to integrate ideas, but speakers think and talk simultaneously. This leads to “the original modality [i.e., a grammatical form] of a composition” (Jahandarie, 1999, p. 132) to differentiate one another; (3) writing includes more passive sentence constructions than speaking does. It means that writing reflects less personal involvement, resulting in higher abstraction, decontextualization, and detachment; (4) speech is more interactive and involves more shared time and space than writing; and (5) speaking is for interpersonal, contextual, and informational purposes, while writing is more suitable for information presentational purposes.

Thus, it seems that speech tends to involve participants more in a given situation and in turn conveys more contextual information than writing, suggesting its efficiency and effectiveness over writing on spontaneous, interactive idea generation task. In this regard, Horowitz and Newman (Horowitz & Berkowitz, 1964, p. 619) scientifically report that “spoken expression, per unit time, produces more material (words, phrases, sentences), more ideas, more repetitions, and elaborations of ideas, and even more irrelevant ideas [, which may further facilitate divergent thinking.] than written expression.” Table 2.3 shows a summary of the comparison between speaking and writing.
Table 2.3. Speaking vs. Writing (or Typing)

<table>
<thead>
<tr>
<th></th>
<th>Speaking</th>
<th>Writing (or Typing)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological organs</td>
<td>Larynx</td>
<td>Fingers, wrist, and arm.</td>
</tr>
<tr>
<td>Sentence structure</td>
<td>Loose</td>
<td>Complex</td>
</tr>
<tr>
<td>Interaction</td>
<td>Spontaneous and involved</td>
<td>Elaborate and detached</td>
</tr>
<tr>
<td>Production mechanism</td>
<td>Natural</td>
<td>Demands physical effort</td>
</tr>
<tr>
<td>Production speed</td>
<td>Faster</td>
<td>Much slower than speaking</td>
</tr>
<tr>
<td>Purpose</td>
<td>Convey and share information</td>
<td>Convey information</td>
</tr>
<tr>
<td></td>
<td>Establish interpersonal relationship</td>
<td></td>
</tr>
</tbody>
</table>

2.2.2 Listening vs. Reading

Listening and reading are the two allied counterparts to speaking and writing, which are the typical channels for idea production, to acquire information and knowledge. Acquisition of intellectual capital implies selection and assimilation of external stimuli, which involves cognitive processing to comprehend oral and written words and sentences, and leads to a view of humans as information processors (Davis, 1974; Galbrath, 1977; Hinsz, Tindale, & Villrath, 1997). In this perspective, memory to store, retrieve, and reproduce information plays a central role. “Memory includes a repository of information as well as mechanisms to capture and to search for information in the repository” (Hoffer & Valacich, 1993, p. 214). As Figure 2.4 shows a general model of a human as an information processor, there are at least three levels of memory: sensory registers, short-term memory (STM), and long-term memory (LTM). Figure 2.5 illustrates the sequence of information processing. Information is first received through sensory registers that reside in sensory memory. Next, attended information moves from
sensory memory to STM, transforming stimuli to mental representations. Then, encoded or rehearsed information that requires structuring and interpretation moves from STM to LTM.

**Figure 2.4. Model of Human as Information Processor**


**Figure 2.5. Three-store Modal Model of Memory**

With the view of humans as information processors, listening and reading show many differences in processing information at all memory levels. As for sensory registers, listening and reading utilize different sensory receptors: ears and eyes. The structures of these two organs to pick up signals are entirely different, at least in two ways: sequentiality and distinctiveness. The following comment by Jahandarie (1999) illustrates this difference.

The speech signal reaches our ears sequentially, one word at a time. The written signal, on the other hand, is perceived in large chunks – that is, several words at a time – with each eye fixation (saccade). Even within each individual word, there is evidence for sequential processing of speech phonemes, as opposed to simultaneous processing of written words … linguistic components are more distinct in writing than in speech. In most writing systems, letters and words are clearly distinguished and separated from each other by spaces. The reader knows where each letter or word starts and where it ends. This should make comprehension a lot easier. Spoken phonemes and words are not separated in that fashion. Except for some pauses at clause boundaries, speech is usually continuous (pp. 152-153).

It seems clear that the structures of the two organs lead to information processing capability of serialism vs. parallelism. The ear is a narrow information bottleneck because of sequentiality, which doesn’t seem to have a solution of increasing the bandwidth and in turn increasing the volume of simultaneous messages, whereas the eye doesn’t seem to have an information bottleneck because of its parallel information searching and chunking capability. Sequentiality further induces retention differences such as recency
and modality effects in short-term and long-term memory when listening and reading. Again, Jahandarie (1999) provides support for this contention.

The recency effect refers to the very robust finding that when participants are required to recall a list of words, syllabus, numbers, and so on, the last few items on the list are recalled better than the earlier items … the modality effect refers to the finding that the recency effect is greater for auditorily presented lists than for visually presented lists (p. 169-170).

It seems clear that retention differences are tightly related to accuracy and efficiency in remembering in human memory. “Accuracy refers to whether or not information is remembered correctly. Efficiency refers to how quickly and easily information can be remembered. Often efficiency can inhibit accuracy, so people trade off accuracy for efficiency in memory, depending on their purpose” (Fiske & Morling, 1995, p. 378). The trade-off between accuracy and efficiency seems to occur due to our very limited capacity to remember about five to nine (7 +/- 2) symbols in our short-term memory (Miller, 1956). As for long-term memory, Newell and Simon (1972; see Nagasumdaram & Dennis, 1993, p. 465-6 for the complete summary) suggest that:

- An external memory (EM) of arbitrary size may be provided to extend the virtual capacity of the STM. (The nature of the external memory is not specified. It could be, for instance, visual or audio, paper or electronic, and so on.)

- In terms of information processing speeds, symbolic information can be accessed more speedily from EM than LTM. Writing to EM is also faster than writing to LTM.
Unlike listening, reading, which is typically based on an external memory in the form of paper, minimizes the retention effects because of no need to memorize.

Based on the above observations, sensory, memory retention differences, and the appropriation of EM between reading and listening clearly indicate theoretically that reading has a clear advantage over listening in the acquisition of intellectual capital if EM is assisted. As studies have shown, the positive effects of using multiple senses, in particular visuals (using visuals improves participant attention, comprehension, retention, agreement, action, and learning), the characteristics of the IPS depicted above, which is the role of EM, explain why reading can be more beneficial than listening. Expanding on the “chunking” advantage of reading not only at the sensory level but also at the internal information processing level, visual attention further allows people to perform a top-down or bottom-up visual search for external information (Chun & Wolfe, 2000). Pinker (1999, p. 3) points out that “the meaning of a spoken word is accessed by a listener’s brain in about a fifth of a second, before the speaker has finished pronouncing it. The meaning of a printed word is registered even more quickly, in about an eight of a second.” The speed of reading comprehension is faster than the speed of listening, facilitating the exploitation and assimilation of information, which may lead to a possibility of generating more creative, novel ideas than listening could generate. In general, listeners tend to recall more of the abstract story due to their limited memory capacity, which is directly related to the trade-off between accuracy and efficiency, and readers tend to recall more specific details of the story by paying attention to all information with the support of EM (Hildyard & Olson, 1982). It has also been estimated that approximately 85% of our intellectual capital is derived from visual sources (e.g.,
EM) (Horowitz & Berkowitz, 1967). Table 2.4 shows a summary of the comparison between reading and listening.

**Table 2.4. Reading vs. Listening**

<table>
<thead>
<tr>
<th></th>
<th>Reading</th>
<th>Listening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological organs</td>
<td>Eyes</td>
<td>Ears</td>
</tr>
<tr>
<td>Sensory storage</td>
<td>Iconic</td>
<td>Echoic</td>
</tr>
<tr>
<td>Information acquisition process</td>
<td>Parallel &amp; Chunking</td>
<td>Serial</td>
</tr>
<tr>
<td>External memory support</td>
<td>No need to memorize</td>
<td>Even with EM, recency effects</td>
</tr>
<tr>
<td></td>
<td>Top-down or bottom-up search</td>
<td></td>
</tr>
<tr>
<td></td>
<td>possible</td>
<td></td>
</tr>
</tbody>
</table>

**2.2.3 Integration Between Speaking and Reading**

Thus far, the different conditions of speaking vs. writing as a means of information production and reading vs. listening as a means of information acquisition have been compared and contrasted. Then, an argument of speaking over typing for information production and reading over listening for information acquisition was presented. The linguistic comparison between speaking and writing (or typing) further points out theoretically and practically that typing takes not only more time but it also has lower physiological and cognitive efficiency in producing ideas. The comparison between reading and listening also clearly shows that reading using EM and the speed of comprehension have a clear advantage over listening in the acquisition of intellectual capital.
In addition, as speaking and listening and writing and reading go hand in hand in natural communication modes, (1) speaking and listening can be viewed as face-to-face interacting group brainstorming of which the main advantage is rich resource conveyance and sharability, and of which the main disadvantage is production blocking and (2) writing and reading can be viewed as nominal group brainstorming of which the major advantage is no production blocking and of which the major disadvantage is no cognitive stimulation or synergy from others’ contributions because individuals work independently. Although electronic brainstorming combines and harnesses the strengths of both verbal (rich resource conveyance and sharability) and nominal brainstorming (no production blocking) with the support of technology features, the fundamental limitation of typing, which is the slower speed of idea production than speaking, may reduce the amount of information available to the group, which is process loss in group interaction (Nunamaker et al., 1991). This may further limit the group’s access to a wider range of information, which can lead to an incomplete use of the information available and will be detrimental to group information processing (Hoffer & Valacich, 1993). In other words, there is a mismatch between idea generation tasks and the aspect of technology (i.e., typing) used in EBS to deliver intellectual capital.

Thus, taken together, Verbal-EBS\textsuperscript{7} disrupts natural communication modes and combines the best of both modes (i.e., speaking and reading) to increase idea production

\textsuperscript{7} This term is used for both nominal Verbal-EBS and interacting Verbal-EBS. The two types of Verbal-EBS will be further distinguished in hypothesis 2. As for nominal Verbal-EBS, Valacich et al. (1994a) compared the performance between paper-and-pencil nominal and EBS nominal and found no performance difference.
time and to enhance cognitive stimulation in idea generation in the context of electronic brainstorming. Verbal-EBS can be configured by integrating two technologies, speech recognition for voice input and group memory, one of EBS’s built-ins, for reading. Automated voice input seamlessly dictates as participants speak their ideas into EBS, while group memory captures all contributions and displays them on a computer screen to read. This completes the common suggestion made earlier by computer-mediated group studies: speaking is faster than typing, while reading is faster than listening. Alternatively, the combination between speaking and reading can be viewed as a marriage between human and computer strengths because humans read and process information and generate creative ideas, and computers convert voice input to a text, maintain all records, and display it on computer screen (see Table 2.5 for more details).

**Table 2.5. Human and Computer Strengths and Weaknesses**


<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Humans</strong></td>
<td></td>
</tr>
<tr>
<td>Pattern recognition</td>
<td>Low-capacity STM</td>
</tr>
<tr>
<td>Selective attention</td>
<td>Fast-decaying STM</td>
</tr>
<tr>
<td>Capacity to learn</td>
<td>Slow processing</td>
</tr>
<tr>
<td>Infinite-capacity LTM</td>
<td>Error prone</td>
</tr>
<tr>
<td>Rich, multikeyed LTM</td>
<td>Unreliable access to LTM</td>
</tr>
<tr>
<td><strong>Computers</strong></td>
<td></td>
</tr>
<tr>
<td>High-capacity memory</td>
<td>Simple template matching</td>
</tr>
<tr>
<td>Permanent memory</td>
<td>Limited learning capacity</td>
</tr>
<tr>
<td>Fast processing</td>
<td>Limited capacity LTM</td>
</tr>
<tr>
<td>Error-free processing</td>
<td>Limited data integration</td>
</tr>
<tr>
<td>Reliable memory access</td>
<td></td>
</tr>
</tbody>
</table>
Although Verbal-EBS loses many channels (e.g., speech tone, facial expressions, gestures, and paralanguage) because of communication via the computer network (but, this is preferred for the conveyance of intellectual capital in an idea generation task), (1) speaking is expected to be less elaborative, brings more contextual information, and has simpler sentence structures than writing; and (2) reading allows for faster information comprehension than listening. The reader can skim an entire text in a few seconds, but the listener must comprehend language as it is produced. As a result, Verbal-EBS takes less time to chunk ideas, cognitively comprehend them, and in turn speed up on idea building. Based on the support provided above, Verbal-EBS is envisioned in this study to be the most ideal EBS. Huber (1990) provides support for the importance of this vision: “any significant advance in information technologies increases communication capabilities, and can falsify hypothesized relationships developed by past research” (Huber, 1990, p. 67).

Thus, it is hypothesized that:

**H1: Individuals in the verbal-EBS condition will outperform individuals in the Typing-EBS condition regardless of group type.**

Researchers promoting electronic brainstorming have theorized that the superior performance of EBS comes from three factors: (1) elimination of production blocking, (2) reduction of redundant idea submission because participants can view prior ideas, and (3) cognitive stimulation or synergy by reading the ideas of others. Regarding the benefits related to cognitive stimulation, numerous prior studies have suggested a much less significant influence of cognitive stimulation (i.e., the value of seeing the ideas of others) on the ideation performance of interacting groups (e.g., Barki & Pinsonneault, 2001;
Connolly, Routhieaux, & Schneider, 1993; Diehl & Stroebe, 1987; Dugosh, Paulus, Roland, & Yang, 2000; Garfield, Taylor, Dennis, & Satzinger, 2001; Paulus, Larey, & Ortega, 1995; Potter, 1997; Sosik, Avolio, & Kahai, 1998). One possible explanation of why individuals are not necessarily obtaining large stimulation benefits from the group interaction process could possibly be the lack of attention to the stimuli, which is one of the most important factors in developing cognitive stimulation or synergy (Dennis & Williams, 2003) due to attention blocking because most participants are busy typing in their own comments most of the time (Straus, 1996; see also Valacich et al., 1993, p. 461), missing relevant and important ideas by others to stimulate creative, cognitive synergy at the right time. This is more significant in EBS groups than in face-to-face groups (Dennis, Himer, & Taylor, 1997/1998) because ideas contributed can be difficult to ignore when a participant has the floor in face-to-face groups. Another plausible explanation derives from the comparison between speaking and typing. Despite Diehl and Stroebe’s (1987, p. 502) suggestion that “[group brainstorming] is practically effortless and involves no time costs,” EBS does require participants’ physiological and cognitive efforts: (1) typing demands more labored mechanism of the fingers, wrist, and arm, leading to an emergence of ergonomics to minimize physical effort; (2) typing divides participants' cognitive attention between typing and viewing a computer screen, which may lead to missing the right stimuli at the right moment; (3) typing induces “cognitive blocking” psychologically because of “the greater amount of screening taking place under writing condition” (Lamm & Trommsdorff, 1973), because written expression requires a more serious commitment, and (4) group brainstorming requires a great deal of cognitive effort to assimilate others' ideas and to associate close and, in particular, distant
meanings to produce quality ideas (Cohen & Levinthal, 1990; Hender, Dean, Rogers, & Nunamaker, 2002; Jessup & George, 1997). Largely, three reasons (lack of attention to stimuli, physiological and cognitive efforts, and cognitive blocking), which all occur by the same typing, combined together may lead to Paulus et al.’s (1995, p. 261) finding that “electronic brainstorming procedures do not match the output of nominal groups that respond orally.”

In interacting Verbal-EBS, voice input eliminates typing, and parallel input removes turn taking. In other words, it is argued that interacting Verbal-EBS, which combines voice input and parallel input, eliminates production blocking. Participants neither need to concentrate on remembering (or rehearsing or suppressing) their ideas nor divide their cognitive attention between typing and stimuli in STM. Thus, this expanded availability frees up their STMs for processing additional ideas. Meanwhile, a group memory as an external memory records and stores all electronic comments of others’ ideas, which reduces cognitive deficiencies of human memory such as failure to remember the ideas of others and incomplete use of information. Although “ideas generated simultaneously by multiple participants cannot all be attended to memory by participants because of the serial nature of the human information processing system” (Benbasat & Lim, 2000, p. 172), once ideas accumulate, the group memory facilitates more effective information processing by allowing participants to read the ideas of others. As pointed out above in the listening and reading section, the nature of reading functions similar to parallel information processing because of chunking capability of the

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8 Paulus et al. (1995) used a tape recorder in their experiment.
eye. This facilitates further information processing by visual top-down or bottom-up search. Jahandarie (1999) states that:

The permanence of written texts allows the reader to use grossly nonlinear processing strategies to advantage. One can scan a page looking for key words or phrases; skim for gist and then focus selectively on particularly salient segments; reread specific portions of the text in order to clarify points and refresh one’s memory; juxtapose in time the reading of noncontiguous segments as one might wish to do, for example, to check the consistency of one part of a text with another” (Jahandarie 1999, p. 135).

This leads to a deeper assimilation of others’ ideas and stimulates learning by sharing different, diverse ideas among group members (Hoffer & Valacich, 1993). Thus, in interactive Verbal-EBS, Verbal-EBS mitigates the potential problems of why individuals are not necessarily obtaining large stimulation benefits (1) by eliminating both attention blockings because of no need to listen to others’ contributions and no need to key in ideas and (2) by reducing physical and cognitive efforts. This makes participants’ dual-processing truly possible and supports the idea that “Searching for good ideas to build on is possible while speaking, but not while writing or typing.”

In sum, interacting Verbal-EBS eliminates attention blocking to the stimuli (i.e., the contributions of others) thereby increasing the probability of attention to the stimuli. This evidences the significant effect on cognitive stimulation (Dugosh et al., 2001) and facilitates information sharing and learning, which are primary goals of the group process (Hoffer & Valacich, 1993).

Thus, it is hypothesized that:
H2: Communication medium (verbal vs. typing) will interact with group type (interacting vs. nominal) such that individuals in the verbal/interacting group condition will have the highest performance.

Studies (Gallupe, DeSanctis, & Dickson, 1988; Hiltz, Johnson, & Turoff, 1987; Parks & Sanna, 1999) frequently suggest that deindividuation of computer-mediated groups leads to less satisfaction than in face-to-face groups. In particular, Jessup and Tansik (1991) and Sosik et al. (1998) point out that anonymity supported by traditional EBS detaches a group member’s attachment to his or her comments. Given prior studies’ suggestions, it is speculated that part of the explanation of deindividuation might be in the nature of writing. As pointed out in the speaking vs. writing section, the nature of writing includes more passive voice in sentences, which means less personal involvement, resulting in higher abstraction, decontextualization, and detachment. In other words, writing is more adequate for highly objective informational tasks that require some degree of detachment between participants such as judgment, decision-making, or negotiation tasks (Biber, 1988) whereas, speech usually occurs in the process of interpersonal interaction. For this reason, oral discourse is accompanied by a greater sense of involvement, which is more “phatic.”

Although the definitions of involvement and detachment, which are the two characteristics to distinguish speaking and writing, may not be adequate in traditional Typing-EBS context because participants can still dynamically interact with one another through the electronic channel, Verbal-EBS that simulates participants to speak ideas and

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9 A psychological state in which group members become less self-conscious and less differentiated from other group members (Diener, 1980; Sosik et al., 1998, p. 10).
respond to the ideas of others as if they were conversing with others (but, without nonverbal cues) seems more playful due to reduced efforts both cognitively and physiologically (e.g., elimination of attention blocking and typing). Webster and Martocchio (1992) suggest that computer playfulness is positively related to involvement and satisfaction. Venkatesh (2000, p. 349) further suggests that “higher levels of computer playfulness lower perceptions of effort – i.e., for the same level of actual effort/time invested, perceptions of effort/time will be lower in the case of a more “playful” user when compared to a less “playful” user.” It is expected that this will lead to an increased perceived interaction and, in turn, a better satisfaction than traditional Typing-EBS.

Thus, it is hypothesized that:

**H3: Individuals in the Verbal-EBS condition will have higher satisfaction than individuals in the Typing-EBS condition regardless of group type.**

### 2.3 Summary

This chapter began with a comprehensive literature review in multiple paradigms: group and cognitive psychology and orality in communication. It was theoretically and practically argued that typing may cause several blockings (such as physiological, psychological, cognitive, attention, production) that were unknown and even overlooked in the past. For example, three types of production blocking have been known (i.e., attenuation blocking, concentration blocking, and attention blocking). But, because that typing is slower than speaking, typing hinders production blocking in terms of information conveyance, and that hasn’t been considered.
Based on a little theory from multiple paradigms, it was argued that Verbal-EBS may perform better than Typing-EBS and other means in general. The next chapter will provide a discussion of the research methods of this study, including research design, artificial group environment, dependent variables, and procedures.
CHAPTER THREE

METHODS

This chapter provides a detailed description of the methodology used for testing the hypotheses. It includes the meticulous operationalization of a group environment using simulation, along with voice recognition manipulation and the experimental procedures, in conducting the study.

Note: This is the first study that investigates the effect of voice input on idea generation performance (both interacting and non-interacting groups). As an initial step toward the investigation of the effect of voice input in real groups, this study examines how individuals may perform differently when given a voice input treatment. As for interacting groups, a group size is set to five, which is reasonable as a start.

3.1 Research Design

A 2X2 factorial design (see Figure 3.1) was used, crossing group type (nominal and interacting group) and communication medium (Typing-EBS and Verbal-EBS). As for using nominal Typing-EBS, the rationale is that Valacich et al. (1994a) compared the performance between paper-and-pencil-based nominal and EBS-based nominal and reported no statistical difference in the performance.
3.2 Interacting Group Manipulation

To control error variance that inevitably occurs in interacting groups (Garfield et al., 2001; Hilmer & Dennis, 2001), a simulator was designed to accurately control the idea stimulation manipulation and to allow for a more accurate measure of individual performance. The level of analysis using a simulator is individual. “A group simulator looks and acts like a groupware system, but instead of sharing ideas among participants, the simulator presents participants with comments that appear to be from other participants but which are, in fact, drawn from a database of preset ideas” (Garfield et al. 2001, p. 327). The simulator precisely mimics the sequence of a real group idea generation session in a way that idea seeds are presented to the subjects. That is a downward linear relationship between the number of idea generation and time in a real group idea generation session (see Connolly et al., 1993). This relationship is represented by many ideas in the early stage and fewer responses toward the later stages, running out of ideas in the end. A series of pilot studies was used to verify that the simulator
accurately mimiced the sequence and interactions of real group idea generation sessions. As a check to verify that subjects indeed believed that they were actually interacting with other subjects, and not a simulator, a post-session question asked each subject, “How many people do you think you were working with on this task?” On average, subjects reported 4.29 members ($SD = 0.988$). Thus, it appears that subjects believed that they were working in an interactive group, further validating this approach for enforcing greater experimental control and for examining individual-level factors in groups. Finally, fifty idea seeds were used because pilot studies with interacting groups of size five for this task generated approximately this number of ideas after removing redundancies. Thus, during the experiment, the simulator randomly picked and displayed an average of forty preset ideas from the database.

3.3 Idea Stimulation Manipulation

For the idea stimulation manipulation, several actual group idea generation sessions were first conducted to collect a large pool of ideas with the experimental task using a similar subject pool. For these sessions, the group size was five members. After removing redundancies, 193 unique ideas were identified by all pilot groups. Three experts, senior employees from the campus Department of Parking Services, were then asked to rate the magnitude of impact of the proposed items using the 7-point Likert scale (anchored by 1, “a very poor solution,” and 7, “a very good solution”). The mean of the three ratings was used as an index of the quality of each idea. Since the outcomes of group idea generation is typically a mixture of low- and high-quality ideas, from the
precoded master list, we randomly selected 50 ideas: 25 high quality ideas (M = 4.813) and 25 low quality ideas (M = 1.147). Any ideas assessed as “ridiculous” by the experts were discarded from further consideration. A Cronbach’s inter-rater reliability of these expert ratings was adequate: 0.93.

3.4 Voice Input Manipulation

The original plan was to use the latest voice-recognition software available on the market such as Dragon Naturally Speaking and IBM Via Voice. We installed both types of software, which are the leading authorities in this area, on the group simulator at WSU’s EMS meeting room and tested them for accuracy and efficiency of the software, which are the most important factors in determining the performance (Rebman, Aiken, & Cegieski, 2003). When the group simulator was activated, the voice input software also was activated to allow participants to speak their ideas, instead of typing. Despite the claim made by the manufacturers (approximately 95% accuracy rate), there were significant limitations: (1) the current state of the technology prevented transcriptions from achieving 100% accuracy, which is a necessary and sufficient condition for this experiment; and (2) it took quite a long training time to reach even 95% accuracy, which requires patience and even commitment. Thus, it was concluded that the current voice recognition software was not yet ready to convince participants to accept this technology as a voice input.

Prior research has referred to “quality ideas” as those with a quality rating of 3 or higher on a 5-point Likert scale (Diehl & Stroebe, 1987; Dennis et al., 1999); since a 7-point scale was used to evaluate ideas here, quality ideas were those with a rating of 4 or higher.
As an alternative, a professional typist who was able to transcribe participants’ ideas at their regular rate of speech was used.

3.5 Subjects

100 undergraduate upper-division business students after controlling for international students from a large state university in the US served as subjects. Pilot studies found that international students generated significantly fewer ideas than domestic students for the task selected. In addition, (1) speaking out their ideas freely in real time seems unnatural compared to spoken English; and (2) the accuracy of voice recognition software is based on the pre-recorded sound of native tongues. The average age of the students was 21 years and 62 percent were male. After stratifying the subject pool described above, subjects were randomly assigned to one of four experimental conditions.

3.6 Task

Subjects were asked to generate ideas on “How can we improve the university’s parking problem?” This task was chosen for its high relevance to the subjects because it stimulates participants to draw on their personal knowledge and experience and it has been used in many prior studies (e.g., Connolly et al., 1990; Garfield et al., 2001; Jessup, Connolly, & Galegher, 1990).

3.7 Control Variables

Group size, international students, task, and time were controlled in this study.

3.8 Dependent Variables

The dependent variables were quantity and quality of ideas after removing redundant ideas. The manner by which these performance measures were operationalized
is consistent with many prior studies (Connolly et al., 1990; Diehl & Stroebe, 1987).
Also, any ideas generated that were not identified prior to the experimental sessions (i.e.,
that were not on the master list developed by the pre-session groups) were also evaluated
for quality by the same three expert raters as described above and included in each
subject’s final performance scores. A Cronbach’s inter-rater reliability of these expert
ratings was adequate: 0.8823.

3.9 Procedures

3.9.1 Nominal Typing-EBS

On reporting to the experimental site (see Figure 3.2), participants were assigned
to a workstation in a computer classroom that contained approximately fifty separate
workstations. The number of subjects that participated in each session ranged from 10 to
20. Subjects were asked to sit in every other seat to prevent any possible social influence
on each other. (During pilot studies, it was observed that despite the instruction not to
talk to each other during the experiment, subjects frequently compared their ideas and
laughed.) Subjects were told that they would work independently using a groupware
system. All subjects were allowed to become familiar with the operation of the
simulator\textsuperscript{11} prior to the main task by first working on a practice task. They were told that
their contributions were anonymous and their results would be used to improve the
campus-parking problem. After 15 minutes (the simulator was programmed to shut down
automatically after 15 minutes), the participants completed a brief questionnaire. To
prevent contamination effect, the participants were asked not to divulge information

\textsuperscript{11} The simulator without database connection can serve as an electronic brainstorming
system.
regarding the experiment with other subjects who would be participating in later sessions until the data collection was complete. The participants were then released.
Figure 3.2. Experimental Setting for Nominal Typing-EBS
3.9.2 Nominal Verbal-EBS

This manipulation was done on a one-on-one basis due to the nature of the experiment. On reporting to the experimental site (see Figure 3.3), each participant was led to a workstation. Participants were told that they would work independently; the workstation had the latest voice recognition software installed; and thus participants had no need to type their ideas. In fact, the professional typist was sitting in the other room, listening to what they had to say through a wireless communication device, which was hidden in the experimental room. Participants were allowed to become familiar with the operation of the simulator and voice input by first working on a practice task. They were told that their contributions were anonymous and their results would be used to improve the campus-parking problem. After 15 minutes (the simulator was programmed to shut down automatically after 15 minutes), the participants completed a brief questionnaire. To prevent contamination effect, the participants were asked not to divulge information regarding the experiment with other subjects who would be participating in later sessions until the data collection was complete. The participants were then released.
Figure 3.3. Experimental Setting for Nominal Verbal-EBS

3.9.3 Interacting Typing-EBS

On reporting to the experimental site (see Figure 3.4), participants were assigned to a workstation in a computer classroom that contained approximately fifty separate workstations. The number of subjects that participated in each session ranged from 10 to 20. Subjects were asked to sit in every other seat to prevent any possible social influence on each other. (During pilot studies, it was observed that despite the instruction not to talk to each other during the experiment, subjects frequently compared their ideas and laughed.) Subjects were told that they would work with other team members who were located randomly throughout the room using a groupware system that would allow them to exchange ideas. All subjects were allowed to become familiar with the operation of the simulator prior to the main task by first working on a practice task. Each subject’s contributions were anonymous. The experimenter then read aloud the experimental instructions while the participants followed in their own copies. Specifically, participants were given a version of Osborn’s (1957) brainstorming rules and were instructed to follow them. The rules directed students to generate as many ideas as possible, to withhold criticism, to include wild ideas, and to build on the ideas of others. They were also told that their results would be used to improve the campus-parking problem. After 15 minutes (the simulator was programmed to shut down automatically after 15 minutes), the participants completed a brief questionnaire. To prevent contamination effect, the participants were asked not to divulge information regarding the experiment with other subjects who would be participating in later sessions until the data collection was complete. The participants were then released.
Figure 3.4. Experimental Setting for Interacting Typing-EBS
3.9.4 Interacting Verbal EBS

This manipulation was done on a one-on-one basis due to the nature of the experiment. On reporting to the experimental site (see Figure 3.5), each participant was led to a workstation. Subjects were told that they would work randomly with other team members who were remotely located in another computer room using a groupware system that would allow them to exchange ideas. They were also informed that the workstation had the latest voice recognition software installed, and thus participants had no need to type their ideas. In fact, the professional typist was sitting in the other room, listening to what they had to say though a wireless communication device, which was hidden in the experimental room. Then, subjects were allowed to become familiar with the operation of the simulator prior to the main task by first working on a practice task. Each subject’s contributions were anonymous. The experimenter then read aloud the experimental instructions while the participants followed in their own copies. Specifically, participants were given a version of Osborn’s (1957) brainstorming rules and were instructed to follow them. The rules directed students to generate as many ideas as possible, to withhold criticism, to include wild ideas, and to build on the ideas of others. They were also told that their results would be used to improve the campus-parking problem. After 15 minutes (the simulator was programmed to shut down automatically after 15 minutes), the participants completed a brief questionnaire. To prevent contamination effect, the participants were asked not to divulge information regarding the experiment with other subjects who would be participating in later sessions until the data collection was complete. The participants were then released.
Figure 3.5. Experimental Setting for Interacting Verbal-EBS

3.10 Summary

This chapter provided an in-depth discussion of the research methods used to collect the data from the experimental participants. In particular, the rationale of using simulation, the manipulation of voice input, and the procedures, which put a simulator and a voice input device together in action, was delineated. The next chapter will discuss the outcomes obtained from the hypothesis testing processes.
CHAPTER FOUR

RESULTS

This short chapter discusses the results obtained from the data analysis. The data analysis techniques (i.e., content coding, solution ratings, and manipulation check) used in this study are described in the methods chapter.

4.1 Results

Table 4.1 and 4.2 present a summary of the means, standard deviations, and results from the ANOVA analysis for individual performance. Hypothesis 1, which stated that individuals in the verbal-EBS condition will outperform individuals in the Typing-EBS condition regardless of group type, was supported. A two-way ANOVA showed a significant effect of communication medium on performance (# of ideas: $F(1, 96) = 53.73, p = <.000$; quality score total: $F(1, 96) = 106.12, p = <.000$). Hypothesis 2, which stated that communication medium (verbal vs. typing) will interact with group type (interacting vs. nominal) such that individuals in the verbal / interacting group condition will have the highest performance, was not supported. A two-way ANOVA showed (1) a main effect of communication medium ($F(1, 96) = 53.73, p = <.000$) and of group type ($F(1, 96) = 5.26, p = .024$) on the # of ideas; (2) a main effect of communication medium ($F(1, 96) = 106.12, p = <.000$) but not of group type ($F(1, 96) = 0.00, p = 0.947$) on the quality score total; and (3) no significant interaction effect between the two factors (# of ideas: $F(1, 96) = 0.09, p = >.05$; quality score total: $F(1, 96) = 0.14, p = >.05$). Hypothesis 3, which stated that individuals in the Verbal-EBS condition will have higher satisfaction than individuals in the Typing-EBS condition, was not supported. A two-way ANOVA showed no statistically significant difference in satisfaction ($F(1, 96) = 0.04, p = .844$).
Table 4.1. Mean and Standard Deviation Score

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Treatment condition</th>
<th>Nominal Typing-EBS</th>
<th>Interacting Typing-EBS</th>
<th>Nominal Verbal-EBS</th>
<th>Interacting Verbal-EBS</th>
</tr>
</thead>
<tbody>
<tr>
<td># of ideas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>7.800</td>
<td>9.400</td>
<td>13.440</td>
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<td>SD</td>
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</tr>
<tr>
<td>M</td>
<td>24.234</td>
<td>23.554</td>
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<td>SD</td>
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<td>8.603</td>
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<td>12.699</td>
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<td>Satisfaction</td>
<td></td>
<td></td>
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<td>SD</td>
<td>3.032</td>
<td>3.744</td>
<td>2.920</td>
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Table 4.2. Statistical Results

<table>
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<tr>
<th></th>
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<th>P</th>
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<tbody>
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<tr>
<td># of ideas</td>
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<tr>
<td>Quality score total</td>
<td>106.12</td>
<td>.000</td>
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<tr>
<td>H2:</td>
<td></td>
<td></td>
</tr>
<tr>
<td># of ideas</td>
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<tr>
<td>C_M</td>
<td>53.73</td>
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<tr>
<td>G_T</td>
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<tr>
<td>C_M * G_T</td>
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<td>.765</td>
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</tr>
<tr>
<td>C_M</td>
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<td>.000</td>
</tr>
<tr>
<td>G_T</td>
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</tr>
<tr>
<td>C_M * G_T</td>
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<td>.709</td>
</tr>
<tr>
<td>H3:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Satisfaction</td>
<td>0.039</td>
<td>.844</td>
</tr>
</tbody>
</table>

*C_M: Communication Medium; G_T: Group Type
4.2 Summary

This chapter provided a statistical description of the hypotheses testing. As for hypothesis 1 (i.e., the performance comparison between voice input and typing), there was a significant performance difference, as predicted that speaking is faster and less elaborative than typing. However, contrary to the predictions, there was no interaction between the factors (hypothesis 2), and Verbal-EBS did not show higher satisfaction than Typing-EBS (hypothesis 3). The next chapter will discuss an interpretation of the study’s outcomes in depth.
CHAPTER FIVE

DISCUSSION

The prime objectives of this study were (1) to explore the potentials of Verbal-EBS to increase the performance in an idea generation task and (2) to enhance our understanding of how and why Verbal-EBS is theoretically and practically different from traditional Typing-EBS. We argued that Typing-EBS *mitigates* production blocking, while Verbal-EBS (1) *eliminates* production blocking by integrating voice input and parallel input and (2) facilitates cognitive stimulation because of hands-and-eyes-free operation. The literature of group brainstorming has posited numerous times that verbalization of ideas is the most ideal method in the context of electronic brainstorming. However, in computing, this has only been realized commercially in recent years as we begin to unravel how the human brain recognizes the spoken word. Given the industry’s unprecedented attention and dedication of resources to voice recognition, the current study addresses an issue that has both practical and relevant significance. The following quote by Benbasat and Zmud supports the need for relevant research especially in terms of emerging technology

Too often, studies that focus on new technologies are published far past the date when the technology could be considered "new." Needless to say, pronouncements in the future about today's technological and associated business challenges are just not going to be considered relevant by most practitioners (Benbasat and Zmud, 1999, p. 6).

Accordingly, based on a conceptual framework, which is grounded in the area of group and cognitive psychology and orality in communication, this study pursued the following
questions: (1) Is voice input better for idea entry than typing? and (2) Is voice input better for interactive electronic group brainstorming? Then, focused hypotheses were developed and tested in controlled laboratory experiments using a group simulator.

The discussion of the results consists of three subsections. The first section discusses the interpretation of the data analysis. The second section discusses implications for research. The third section discusses implications for practice.

5.1 Interpretation of Research Results

The study reported was conducted to enhance our current understanding of the effect of voice input on idea generation performance in computer-mediated groups. In particular, the current study examined whether or not group performance using a Verbal-EBS different from traditional Typing-EBS based on orality research in communication. It was theorized that speaking & writing (or typing) in terms of information production and exchange and reading & listening in terms of information acquisition are very different from each other. Based on the theoretical framework that was developed, the current study combined and applied the best of both communication modes in the context of electronic brainstorming. As envisioned, the central finding in the study is that individuals in the verbal treatment, regardless of group type, performed twice as well as individuals in the typing treatment (see Figure 5.1).
The general findings are as follows:

1. Sub-group analysis between nominal Typing-EBS and interacting Typing-EBS

   There was no statistical performance difference between individuals with nominal Typing-EBS treatment and individuals with interacting Typing-EBS treatment (see Figure 5.2). As a reminder to the reader, the level of analysis in this study is individual which was facilitated by the use of the group simulator. Since the group size using the simulator was five, the findings are consistent with prior findings that in smaller groups, the performance of EBS groups is no worse than that of pooled nominal groups.
2. Sub-group analysis between nominal Verbal-EBS and interacting Verbal-EBS

There was also no performance difference between individuals with nominal verbal-EBS treatment and individuals with interacting verbal-EBS treatment (see Figure 5.3). The data clearly show that despite the procedural instruction (i.e., Osborn's rules), individuals who were given interactive verbal-EBS treatment showed a strong tendency of engaging in a discussion on the ideas of others. It was reasoned that the characteristic of speaking (i.e., rather effortless and spontaneous) allowed the subjects to engage in real interaction / conversation on the ideas of others, even though it was computer-mediated and idea seeds were drawn from a database. On the other hand, the current study found no such phenomenon in nominal verbal treatment. In fact, it was theorized in the speaking section that speakers tend to talk in an active voice about their feelings and feel
more involvement with the reality of here and now, making more references to actions and events.

**Figure 5.3. Performance Comparison Between Nominal and Interacting Verbal-EBS**

3. There was no statistical difference in satisfaction between individuals with Verbal-EBS treatment and individuals with Typing-EBS treatment. However, more close examination of the data show that (1) individuals with interacting EBS (regardless of verbal or typing) expressed more satisfaction than individuals with nominal EBS; and (2) individuals with interacting Verbal-EBS expressed the highest satisfaction. As for the individuals with interacting EBS, one interpretation is that people in groups tend to overestimate their performances (Stroebe, Diehl, & Abakoumkin, 1992), which may lead to higher satisfaction. Expanding on the above explanation, interacting
Verbal-EBS subjects may have shown a statistically significant satisfaction difference compared to other treatments. One possible explanation is that although Verbal-EBS is a much easier way to express ideas, the younger generation represented by this sample (a.k.a. the Net generation) has grown accustomed to electronic communication through typing such as e-mail, instant messages, etc. The followings are excerpts from the collected data:

It is easier to type.

I don’t like this speaking thing.

I don’t think the software is that accurate.

I don’t like what I said. I want to edit.

Figure 5.4. Satisfaction Comparison Among Experimental Treatments
Nonetheless, the results of this study confirm the significant performance
difference between the verbal and typing treatment. Speaking one’s mind seems much
easier than typing it, and it is much easier to acquire intellectual capital through reading
than listening. As for speaking, its ease of utterance and less effortful mode of expression
are certainly basic factors in performance differences, whereas writing requires a more
serious commitment than speaking, both physiologically and psychologically (Horowitz
& Newman, 1964). Horowitz and Berkowitz (1964, p. 625) further suggest that “…
speaking is a preferred mode and most persons give spoken expression far more
opportunity for practice than written expression. Hence, energy, musculature, ontogeny,
and practice all favor speaking as a medium for expressing ideas.” In addition, the data
shows that speaking produces a far greater quantity of information than writing, since
“spoken expression produces significantly more cognitive and linguistic material than
written expression” (Horowitz & Berkowitz, 1964, p. 619). From this fact, it is possible
to say that quantity helps breed quality. As for reading, its capability to process
information in parallel gives readers an edge to acquire information and generate
creative, novel ideas. In general, speech cannot keep pace with the speeds at which
readers process writing. Combined together, speaking and reading, make dual processing
possible: Searching for good ideas to build on with the support of group memory is
possible while speaking, but not while writing. Alternatively, it is also possible that
separating and working alone but connected with others through the network further
facilitates participants to generate ideas because of (1) Valacich et al.’s (1994) finding
that physical proximity reduces the performance of computer-mediated groups; and (2) “a
function of the tendency in speaking to fill in empty space – i.e., silence … this frequently leads to new ideas” (Horowitz & Newman, 1964, p. 647).

In the economic analysis perspective, the costs of the individual contribution (i.e., effort) are an important determinant of the motivation. Typing demands physical and cognitive efforts of tying, divides participants' cognitive attention on keyboarding and a computer screen, and needs more efforts to overcome attention blocking. In addition, writing requires higher cognitive elaboration than speaking; most people try to have a presentable exposition in terms of complete sentences and acceptable grammar and read their production before sending it. (Horowitz & Berkowitz, 1964, p. 625). Speaking ideas is rather effortless and spontaneous, at least reducing physiological effort and some degree of cognitive effort. Economically speaking, less effort needed compared to writing naturally motivates participants and allows them to capitalize on others’ ideas by focusing more on attending and comprehending information and generating better ideas.

5.2 Implication for Research

Based on the central finding of this study (i.e., individuals with a voice input treatment performed nearly twice as well as individuals with a typing treatment), there is an opportunity to extend this study to a real group interaction with voice input using professional typists. Due to operationalization conflicts in same time / same place groups because of cognitive interruption that occurs when participants speak their ideas and software complications that make it hard to distinguish participants’ voices, distributed groups need to be utilized. However, in fact, prior studies show that (1) physical proximity reduces the performance of computer-mediated groups (Valacich et al. 1994); and (2) although the presence of others has a positive effect (called social facilitation)
(Bond & Titus 1983), Paulus and Dzindolet (1993) conclude that in group brainstorming, the effect of others’ presence is not sufficient enough to influence the outcomes.

The general Finding 2 in the discussion section provides a clue to overcome Paulus et al.’s (1995, p. 261) finding that “electronic brainstorming procedures do not match the output of nominal groups that respond orally.” The data found no individual performance difference between interacting Verbal-EBS and nominal Verbal-EBS due to the tendency of individuals in interacting Verbal-EBS engaging in spontaneous arguments with the ideas of others. This finding leads to reinforcement of Osborn’s group brainstorming rules in idea generation sessions. Wheeler and Valacich (1996) point out that procedural guidance (i.e., brainstorming rules) lacks the ability to restrict the group interaction process in exchanging ideas and suggests a new set of EBS technology features that could remind participants to follow rules. Good examples are such as periodical time-based popup announcements or artificial intelligence based techniques that recognize specific words as cues to trigger specific reminders.

Simulation has been a common practice in all disciplines in situations where an outcome does not meet the assumptions. Good examples under management science are (1) Monte Carlo simulation, which estimates the distribution of an outcome variable that depends on several probabilistic input variables and (2) systems simulation that explicitly models sequences of events that occur over time (Evans & Olson, 1998, p. 6). There has been a surge of simulated group idea generation studies in recent years (e.g., Satzinger et al. 1999; Garfield et al. 2001; Hilmer & Dennis 2001). The application of a group simulator is promising for future research Connolly et al. (1993) point out that cognitive and motivational domains remain an uncharted territory and urged us to pursue an
individual-level approach to investigate cognitive and motivational stimulation. Since the level of analysis using a simulator is individual, it opens up many possibilities to explore new factors that may influence cognitive and motivational stimulation. Also, the use of a simulator dramatically reduces the number of subjects needed but simultaneously increases the statistical power by controlling error variance and less precision in the measures that inevitably occur in actual, interacting groups (Hilmer & Dennis 2001).

“‘To the user, the system is the interface’” (Gray, Mandviwalla, Olfman, & Satzinger, 1993, p. 192; Moran, 1981). This is the most critical component of GSS, in general a management information system, between the system and its users. For the user, the system-user interface is the only part of the system that is meaningful, and the rest is invisible. “[A] goal of the interface is to help users feel like they are reaching right through the computer and directly manipulating the objects they are working with” (Mandel, 1997, p. 60). As part of the designing GSS interface (see Gray et al., 1993 for detailed issues in design), there are a variety of input devices such as typing, touch screen, mouse, and voice input. Among them, voice input is the only one that does not require the skill and learning time, assuming 100% accuracy of the technology. Conceptually, the integration of voice input and group memory allows humans and computers to work together with the strengths of both parties. Naturally, computer users prefer an easier interface. With the support of the findings in this study, it is strongly believed that human-computer interaction through speech, one of the final frontiers in the human-computer interaction, will open a new era of user-friendly computing.
5.3 Implication for Practice

This study also has relevance for practice. Although the dissemination rate of computers is continuously expanding, many people – in particular, middle-aged managers – are still intimidated by the computers and their accoutrements (Gray et al., 1993). At best, keyboards are perceived as a very inconvenient input mechanism for most decision-makers. Currently, voice input, one of the final frontiers in human-computer interaction, is already in the process of being commonly utilized. It has already impacted many business areas, and will be applied in an every widening range of assistive technologies.

As for group brainstorming, prior studies have indicated that typing requires participants’ physiological and cognitive efforts (e.g., dividing cognitive attention, attention blocking), which are important determinants of motivation. The results of this study will help Groupware designers understand how and why voice input is a more natural human-computer interaction and to consider voice input as a primary user interface – at least in terms of electronic brainstorming. Briggs et al. (1997/1998) point out the slow diffusion of EBS into organizations, and this study may ultimately contribute to the diffusion of Groupware by being more user-friendly, and by showing the potential for noticeable increases in productivity.

5.4 Summary

This chapter provided a discussion of the results of this research. As the central finding shows, individuals who were given Verbal-EBS treatment performed twice as well as individuals with Typing-EBS treatment, thus empirically supporting the suggestions of prior studies in this regard. Contrary to predictions, Interacting Verbal-EBS did not outperform Nominal Verbal-EBS. We theorized that this was due to one of
the characteristics of speaking, which is the opportunity to engage in spontaneous arguments, because procedural guidance (i.e. brainstorming rules) lacks the ability to restrict group interaction process in exchanging ideas. As a possible solution we suggested a new set of EBS technology features that could remind participants to follow rules and guidelines. Related to satisfaction (Verbal-EBS vs. Typing-EBS), this may be due to an environment to which the new generation had become accustomed. In sum, from a theoretical and practical standpoint, the results of this study shed a positive light on the viability of Verbal-EBS.

While this chapter provided an overview of the study results that concluded with a discussion of both the theoretical and practical implications of the findings, the next chapter will provide an overall conclusion of this research and include a discussion of the strengths, limitations, and contributions to the scientific body of knowledge. Concluding remarks will also be provided.
CHAPTER SIX
STRENGTHS, LIMITATIONS, CONTRIBUTIONS, AND CONCLUSION

This chapter first provides a discussion of the strengths and limitations that need to be taken into account while interpreting the research results. Next, the chapter discusses contributions it made to the cumulative body of knowledge. Then, the conclusion of this thesis follows.

6.1 Strengths and limitations

6.1.1 Strengths

Undoubtedly, one of the main strengths of this study is its theoretical approach. The journey started out with the simple facts in human interaction speeds: speaking is faster than typing, and reading is faster than listening. This study theoretically grounded and reconstructed these facts in the context of electronic brainstorming based on the studies in group and cognitive psychology and orality in communication.

Another important strength of the study is its methodological approach. This study employed a laboratory experiment with a goal to maximize precision in the control and measurement of variables (McGrath, 1982). In addition to that, this study deployed a group simulator, which increased the statistical power by controlling error variance and less precision in the measures that inevitably occur in actual, interacting groups (Hilmer & Dennis 2001). Although prior researchers have called for examinations of individual characteristics such as cognition and motivation within an idea generation context (e.g., Connolly et al., 1993), this domain has largely remained unexamined due to the difficulty in separating group and individual-level effects. This research supports the notion that a
group simulator can be used to explore various factors that may influence cognitive stimulation, motivation, and performance within interacting groups.

### 6.1.2 Limitations

There are obvious limitations to the external validity of this study. This study employed a laboratory experiment using student subjects and simulation - although the simulation increases error variance control and precision – which moves away from the natural group settings. However, the purpose of the laboratory experiment is to test a model or theory based on precision (McGrath, 1982; Parks & Sanna, 1999). As for using the simulation, it was necessary because (1) we examine individual performance; and (2) subjects who speak out in a real, interacting group distract and block other participants’ idea generation. Nonetheless, additional research is necessary to understand the extent to which these findings may generalize to different environments and different individuals.

Another limitation is related to the lack of sophistication of current technology: speech recognition is not yet at “Star Trek” level. Ease of use is one of the major determinants of intention to use (Davis et al., 1989). The current software on the market was not yet ready to convince participants to accept this technology as a voice input. To customize the software to a specific participant takes too long. Its performance in terms of accuracy and efficiency was severely limited during a real-time conversation, which led to frustration in pilot studies. To benefit from the potentials of voice input, users have to wait until the technology improves its performance.

Another limitation is related to unequal gender distribution of subjects. This study however, ran t-tests to examine any performance differences based on gender in each experimental condition and found no gender effect. Prior studies (e.g., Herschel, Cooper,
Smith, & Arrington, 1994; Klein & Dologite, 2000) investigated the effect of varying gender composition and found no gender effect in an idea generation task.

6.2 Contributions

Since the main goal of scholars is to contribute to the cumulative body of knowledge and to apply that knowledge to the practitioners (Dennis & Valacich, 2001; Van de Ven, 1989), this study makes a significant contribution to both theory and practice because of its rigor, relevance, and empiricism. Accordingly, hoping to be a timeless classic, this study responds to four questions delineated by Dennis and Valacich (2001).

First, Fundamental Issue. This study fundamentally focused on the issue of human interaction speeds; i.e., speaking is faster than typing and reading is faster than listening. Apparently, the integration of speaking and reading seems to offer the best opportunity to increase the performance in the context of electronic brainstorming. This issue has been around for more than several decades. However, it has not been doable due to the extreme technical difficulty on the side of voice recognition. In recent years, voice recognition has become the phenomenon in the industries and businesses because we started to understand how the human brain recognizes the spoken word. It is still in its infancy due in large part to the unknowns of how the human brain decodes speech. Nonetheless, this study with the “final frontier” spirit applied voice recognition to investigate its potentials in the context of electronic brainstorming and brainstorming in general and claims to be the first in this kind. As the results of the study empirically
demonstrated, many interesting research questions and opportunities remain because of many positive things Verbal-EBS has to offer.

Second, News Value. Since the beginning of brainstorming, the idea generation performance of individuals and groups has always been our interest. By the reason of that, prior studies have put an obsession on identifying and developing a new technique or method that is likely to enhance the performance. In particular, the overall performance comparison between Nominal and EBS has been mixed. In addition to that, Paulus et al.’ study (1995, p. 261), which reported “electronic brainstorming procedures do not match the output of nominal groups that respond orally,” makes the debate far from settled. Van de Ven (1986) suggests innovative, novel ideas are nothing but combining old ideas or borrowing ideas in other areas and applying them to a new situation. MIS researchers have applied computing and networking technologies to enhance the idea generation performance. Building on this tradition, this study further pushed the boundary of technology that can offer an even higher level of performance, asking a totally new research question; i.e., is Verbal-EBS better than Typing-EBS or Verbal-Nominal? This led this study to set the record straight as the results of this study empirically show. Also, the results of this study opened up a whole new window of opportunity for further investigation.

Third, Interesting Story. Davis (1971) suggests that interesting theories reverberate far beyond their falsifiability because they are simply interesting. He asserts that “an audience [i.e., reviewers and editors] will consider any particular proposition to be worth saying only if it denies the truth of some part of their routinely held assumption-ground…a theory will be considered truly interesting only if it has repercussions on both
[a theoretical dimension and a practical dimension]” (p. 311). As Huber (1990, p. 67) notes that “any significant advance in information technologies increases communication capabilities, and can falsify hypothesized relationships developed by past research,” this study builds on prior empirical findings and applies voice recognition, one of the latest technologies, in the context of electronic brainstorming and brainstorming in general to enhance our current understanding. Blending academics’ missionary zeal toward a new contribution to knowledge (i.e., to find a new ideation method) and the industry’s unprecedented attention and dedication of resources to voice recognition technology, this study reflects rigor, relevance, and empiricism. In sum, “Oh #&@%, why didn’t I think of that…That’s funny” (Dennis & Valacich, 2001, p. 10).

Fourth, Outcome Independence. Steinfeld and Fulk (1987, p. 480) warrant “Type III error” if without theory. One of the fundamental questions this study asked was “Why should colleagues give credence to this particular representation of the [phenomenon]?” (Whetten, 1989, p. 491) As Van de Ven (1989, p. 486) sums up “Nothing Is Quite So Practical as a Good Theory,” the answer lies in the logical argument underlying the research assumption (i.e., the integration of speaking and reading will perform the best). This study built a theory by stretching its theoretical boundaries to multiple paradigms (group psychology, cognitive psychology, and orality in communication) to discern “What are the underlying [physiological], psychological, economic, or social dynamics that justify the selection of factors and the proposed causal relationship?” (Whetten, 1989, p. 491; see also McKelvey & Aldrich, 1983, p. 108 in particular). This led to the development of the theory that adds another contribution, regardless of the outcomes.
In addition, the development of a group simulator is timely and important. Although prior researchers have called for examinations of cognitive and motivational characteristics within an idea generation context (e.g., Connolly et al., 1993), the domain of individual characteristics has largely remained unexamined due to the difficulty in separating group and individual-level effects. This research supports the notion that a group simulator can be used to explore various factors that may influence cognitive stimulation, motivation, and performance within interacting groups.

6.3 Conclusion

In conclusion, this is the first study that theoretically argued how and why voice input over typing may be more ideal for group brainstorming and empirically tested the effect of Verbal-EBS on cognitive stimulation. The results strongly support that the combination of speaking enabled by voice input and reading supported by group memory is a more desirable medium in an idea generation task. The results of this study also redirect future studies in several different areas such as examination of the effect of voice input in real group settings and group simulation. In particular, the use of the group simulator is an important step forward in the development and refinement of a theory to high precision and allows further investigation in the domain of individual differences.
BIBLIOGRAPHY


Hall, T. (1986). When budding MBAs try to save kool-aid, original ideas are scarce. Wall Street Journal, Nov. 25.


Thank you for taking time to participate in this study. We appreciate your help. Please read the consent information below.

---

Written Consent Form

**Description**: On the day of the experiment, you will be randomly assigned to a team to do a pre-designed task.

**Risks and Benefits**: There are no known risks for participating in this study, and you will receive extra credit at the end of the session to show our appreciation of your participation in this research project.

**Time Involvement**: Your participation will take about 30 minutes.

**Your Rights**: The information in this consent form is provided so that you can decide whether you wish to participate in this study. It is important that you understand that your participation is completely voluntary. This means that even if you agree to participate you are free to withdraw from the experiment at any time, or decline to participate in any portion of the study, without penalty.

**CONSENT STATEMENT**:  
I have read the above comments and agree to participate in this experiment. I understand that if I have any questions or concerns regarding this project I can contact the investigator, Jay Jung, at <Johnson Tower 415, jay@cbe.wsu.edu> or the WSU Institutional Review Board at (509) 335-9661.

---

If you'd like to participate, press begin to start. Otherwise, simply close the Internet browser.
APPENDIX B: QUESTIONNAIRE MEASURES


Satisfaction
1. How do you feel about the process by which you generated ideas?
   - Very dissatisfied
   - Very satisfied
   1  2  3  4  5  6  7

2. How do you feel about the idea proposed?
   - Very dissatisfied
   - Very satisfied
   1  2  3  4  5  6  7

3. All in all, how did you feel?
   - Very dissatisfied
   - Very satisfied
   1  2  3  4  5  6  7

Production Blocking
4. When you thought of an idea, Could you express it immediately
   - Did you have to wait to express it
   1  2  3  4  5  6  7

5. Did you express your ideas
   - Soon after you thought of them
   - after waiting a while
   1  2  3  4  5  6  7

Evaluation Apprehension
6. Did you feel any apprehension about generating your ideas?
   - A lot of apprehension
   - Neutral/undecided
   - No apprehension
   1  2  3  4  5  6  7

7. How at ease were you doing the idea generation session?
   - Definitely not at ease
   - Neutral/undecided
   - Very at ease
   1  2  3  4  5  6  7

Free Riding
8. How much do you feel you participated in this idea generation session?
<table>
<thead>
<tr>
<th>9. How satisfied are you with your own performance on this task?</th>
<th>Very dissatisfied</th>
<th>Very satisfied</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Synergy and Stimulation**

10. How stimulating did you find this task?

<table>
<thead>
<tr>
<th>Not stimulating</th>
<th>Neutral/undecided</th>
<th>Very stimulating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

11. How interesting was this idea generation task?

<table>
<thead>
<tr>
<th>Very uninteresting</th>
<th>Neutral/undecided</th>
<th>Very interesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

12. How motivated were you to generate quality ideas?

<table>
<thead>
<tr>
<th>Definitely not motivated</th>
<th>Neutral/undecided</th>
<th>Very motivated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

**Sufficient Time**

13. For this idea generation session, did you

<table>
<thead>
<tr>
<th>Have as much time as you needed</th>
<th>Want more time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

14. Considering all the ideas you thought of, did you

<table>
<thead>
<tr>
<th>Have time to express all your idea</th>
<th>Not have time to express all ideas</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

**Others**

15. Age?

16. Gender?

| Male | Female |
APPENDIX C: EXPERIMENTAL PROCEDURES


1. Nominal Typing-EBS

Greetings and Introductions:

- Subjects will enter the behavioral laboratory and sign their names to a sign-up sheet.
- Ask participants to sit every other seat.
- After all subjects arrive, experimental materials will be handed out to all participants (task and questionnaires).
- Give all subjects the questionnaire packets.

Script:

Hello, my name is _______________. I will be conducting this experiment. If you have any question, please don't hesitate to ask me.

At this time, please make sure you sign your student id and course and section on the sign-up sheet. It is important that you do this so that we can make sure you receive credit for participating.

[Wait until all subjects have completed signing the sign-up sheet.]

Have you all completed signing the sign-up sheet? Good, now we can continue.

[Go to training task]
Training Task

[Have computer and internet browser on and ready to go.]

Please go to the URL for a training task that is given on the cover of your questionnaire packet.

When you see a small network security window pops up, enter the userid, password, and domain name in the corresponding boxes as I wrote down on the white board and stand by. Please do not hit the “enter” button unless I ask you to do so.

[Wait until all subjects have entered the codes in the network security window. Then, tell them to click the “OK” button simultaneously.]

During this experiment you will work independently on a problem.

[Describe how the technology works.]

On the computer in front of you, there is a screen that has three sections. The upper section shows the agenda. The middle section will display all comments you make. The bottom section allows you to enter new comments. Also, in the upper right corner, there is a clock ticking as you see. During the real task, it will tick for 15 minutes, and the system will shut down automatically.

[Have individuals enter a comment or two into the system on a sample problem.]

At this time I would like you to enter a comment into the system. This comment should address the question displayed at the top section of the window – e.g., Who will win the 2003 NBA finals?

[Now state]

When using this type of system, it is often more effective to send many short messages so that you can see what you are thinking rather one long message.

If you have any comments about how to use the system or if you are having problems with your computer during this experiment, please don't hesitate to ask me for help.

OK, does anyone have any questions? Does everyone understand how to enter comments into the system?

Great!

[Give two or three minutes for more practice.]
[Have participants close the training task browser.]
Experimental Task

[Have internet browser on and ready to go.]

Please go to the URL for the actual task that is given on the cover of your questionnaire packet.

When you see a small network security window pops up, enter the userid, password, and domain name in the corresponding boxes as I indicated on the white board and stand by just like you did with the training task. Please do not hit the “enter” button unless I ask you to do so.

[Wait until all subjects have entered the code in the security window. Then, describe the main task.]

Many students have experienced the frustration of not being able to find a parking space on campus. You are asked to help us resolve the campus parking problem: How can we improve the university’s parking problem? Your ideas will be reviewed and used to improve the parking problem. In this experiment, you will work independently to solve the problem. You will be given 15 minutes. During this experiment, please do not talk – except to ask me questions.

[Tell participants to click the “OK” button simultaneously.]

Please begin working on the task.

[After 15 minutes]

Please fill out the questionnaire.

[Wait for the subjects to finish. If they are done, say the following.]

Thank you very much for your participation. For several weeks until I complete the data collection, please do not talk about the experiment you performed in this lab with other subjects who will be participating in later sessions. Again, thank you for your participation. You may leave now.
2. Interacting Typing-EBS

Greeting and Introductions:

- Subjects will enter the behavioral laboratory and sign their name to a sign-up sheet.
- Ask participants to sit every other seat.
- After all subjects arrive, experimental materials will be handed out to all participants (task and questionnaires).
- Give all subjects the questionnaire packets, which include the group brainstorming rules on the cover.

Script:

Hello, my name is _________________. I will be conducting this experiment. If you have any question, please don’t hesitate to ask me.

At this time, please make sure you sign your student id and course and section on the sign-up sheet. It is important that you do this so that we can make sure you receive credit for participating.

[Wait until all subjects have completed signing the sign-up sheet.]

Have you all completed signing the sign-up sheet? Good, now we can continue.

[Go to training task]
Training Task

[Have computer and internet browser on and ready to go.]

Please go to the URL for a training task that is given on the cover of your questionnaire packet.

When you see a small network security window pops up, enter the userid, password, and domain name in the corresponding boxes as I indicated on the white board and stand by. Please do not hit the “enter” button unless I ask you to do so.

[Wait until all subjects have entered the codes in the network security window. Then, tell them to click the “OK” button simultaneously.]

During this experiment you will work as a group on a problem. When groups work together, they need to communicate. In this experiment you will communicate with your group members by using computers that are networked to one another.

[Describe how the technology works.]

On the computer in front of you, there is a screen that has three sections. The upper section shows the agenda. The middle section will display all comments you make. The bottom section allows you to enter new comments. Also, in the upper right corner, there is a clock ticking as you see. During the real task, it will tick for 15 minutes, and the system will shut down automatically.

[Have groups enter a comment or two into the system on a sample problem.]

At this time I would like you to enter a comment into the system to share with your group members. This comment should address the question displayed at the top of the blue window – e.g., Who will win the 2003 NBA finals?

[Now state]

When using this type of system to do group work, it is often more effective to send many short messages so that your group can see what you are thinking rather one long message.

If you have any comments about how to use the system or if you are having problems with your computer during this experiment, please don't hesitate to ask me for help.

OK, does anyone have any questions? Does everyone understand how to enter comments into the system?

Great!
[Give two or three minutes for more practice.]

[Have participants close the training task browser.]

Experimental Task

[Have internet browser on and ready to go.]

Please go to the URL for the actual task that is given on the cover of your questionnaire packet.

When you see a small network security window pops up, enter the userid, password, and domain name in the corresponding boxes as I indicated on the white board and stand by just like you did with the training task. Please do not hit the “enter” button unless I ask you to do so.

[Wait until all subjects have entered the codes in the security window. Then, describe the group brainstorming rules and the main task.]

Now, I’d like you to look at the cover of your questionnaire packet. It has the rules of group brainstorming. When you work on a task to share your ideas with others, you need to follow these rules.

1. Criticism is ruled out. Withhold your adverse judgment of others’ ideas.
2. “Free-wheeling” is welcomed. The wilder the idea, the better; it is easier to tame down than to think up.
3. Quantity is wanted. The greater the number of ideas, the more the likelihood of useful ideas.
4. Combination and improvement are sought. In addition to contributing ideas of your own, participants should suggest how ideas of others can be turned into better ideas or how two or more ideas can be joined into still another idea.

Does anyone have any questions about the rules of group brainstorming? OK, now let me talk about the real task.

Many students have experienced the frustration of not being able to find a parking space on campus. You are asked to help us resolve the campus parking problem: How can we improve the university’s parking problem? Your ideas will be reviewed and used to improve the parking problem. In this experiment, you will be randomly assigned to a group to solve the problem. You will be given 15 minutes. During this time, please use the computer system for all your group communication. Please do not talk during this experiment – except to ask me questions.

[Tell participants to click the “OK” button simultaneously.]

Please begin working on the task.
[After 15 minutes]

Please fill out the questionnaire.

[Wait for the subjects to finish. If they are done, say the following.]

Thank you very much for your participation. For several weeks until I complete the data collection, please do not talk about the experiment you performed in this lab with other subjects who will be participating in later sessions. Again, thank you for your participation. You may leave now.
3. Nominal Verbal-EBS

Greeting and Introductions:

- A subject will enter the behavioral laboratory and sign his / her name to a sign-up sheet.
- After the subject arrives, experimental materials will be handed out to the participant (task and questionnaires).
- Give the subject the questionnaire packet.

Script:

Hello, my name is ________________. I will be conducting this experiment. If you have any question, please don't hesitate to ask me.

At this time, please make sure you sign your student id and course and section on the sign-up sheet. It is important that you do this so that we can make sure you receive credit for participating.

[Wait until all subjects have completed signing the sign-up sheet.]

Have you completed signing the sign-up sheet? Good, now we can continue.

[Go to training task]
Training Task

[Have computer and internet browser on and ready to go.]

Please go to the URL for a training task that is given on the cover of your questionnaire packet.

When you see a small network security window pops up, enter the userid, password, and domain name in the corresponding boxes as I indicated on the white board and stand by. Please do not hit the “enter” button unless I ask you to do so.

[Wait until the subject has entered the codes in the network security window. Then, tell them to click the “OK” button.]

During this experiment you will work independently on a problem.

[Describe how the technology works.]

On the computer in front of you, there is a screen that has three sections. The upper section shows the agenda. The middle section will display all comments you make. The bottom section allows you to enter new comments. Also, in the upper right corner, there is a clock ticking as you see. During the real task, it will tick for 15 minutes and the system will shut down automatically. Also, the computer has the latest voice recognition software installed so that you don’t need to type your ideas. Just speak your ideas. The software will do the rest. When you speak into the computer, try not to ramble, speak loudly, speak at a constant rate, and try not to mumble. These are recommended by the software manufacturer.

[Have individuals enter a comment or two into the system on a sample problem.]

Please put on the headset in front of you and make yourself comfortable. While I step out of the room, I would like you to speak a comment into the system. This comment should address the question displayed at the top section of the window – e.g., who will win the 2003 NBA finals?

[Return to the lab in 30 seconds or so.]

[Now state]

When using this type of system, it is often more effective to send many short messages so that you can see what you are thinking rather one long message.

If you have any comments about how to use the system or if you are having problems with your computer during this experiment, please don't hesitate to ask me for help.
OK, do you have any questions? Do you understand how to enter comments into the system?

Great!

[Give two or three minutes for more practice.]

I will step out of the lab. Practice several more minutes.

[Step into the lab after several minutes.]

[Have participants close the training task browser.]

Experimental Task

[Have internet browser on and ready to go.]

Please go to the URL for the actual task that is given on the cover of your questionnaire packet.

When you see a small network security window pops up, enter the userid, password, and domain name in the corresponding boxes as I indicated on the white board and stand by just like you did with the training task. Please do not hit the “enter” button unless I ask you to do so.

[Wait until all subjects have entered the code in the security window. Then, describe the main task.]

Many students have experienced the frustration of not being able to find a parking space on campus. You are asked to help us resolve the campus parking problem: How can we improve the university’s parking problem? Your ideas will be reviewed and used to improve the parking problem. In this experiment, you will work independently to solve the problem. You will be given 15 minutes.

[Tell participants to click the “OK” button simultaneously.]

Please begin working on the task.

[Step out of the lab]

[Step into the lab after 15 minutes]

Please fill out the questionnaire.

[Wait for the subjects to finish. If they are done, say the following.]
Thank you very much for your participation. For several weeks until I complete the data collection, please do not talk about the experiment you performed in this lab with other subjects who will be participating in later sessions. Again, thank you for your participation. You may leave now.
4. Interacting Verbal-EBS

Greetings and Introductions:

- A subject will enter the behavioral laboratory and sign his / her name to a sign-up sheet.
- After the subject arrives, experimental materials will be handed out to the participant (task and questionnaires).
- Give the subject the questionnaire packet, which includes the group brainstorming rules on the cover.

Script:

Hello, my name is ________________. I will be conducting this experiment. If you have any question, please don't hesitate to ask me.

At this time, please make sure you sign your student id and course and section on the sign-up sheet. It is important that you do this so that we can make sure you receive credit for participating.

[Wait until all subjects have completed signing the sign-up sheet.]

Have you completed signing the sign-up sheet? Good, now we can continue.

[Go to training task]
Training Task

[Have computer and internet browser on and ready to go.]

Please go to the URL for a training task that is given on the cover of your questionnaire packet.

When you see a small network security window pops up, enter the userid, password, and domain name in the corresponding boxes as I indicated on the white board and stand by. Please do not hit the “enter” button unless I ask you to do so.

[Wait until the subject has entered the codes in the network security window. Then, tell them to click the “OK” button.]

During this experiment you will be randomly assigned to a group to work on a problem. Other team members are remotely located in another computer room using a Groupware system that would allow you and your team members to exchange ideas.

[Describe how the technology works.]

On the computer in front of you, there is a screen that has three sections. The upper section shows the agenda. The middle section will display all comments you make. The bottom section allows you to enter new comments. Also, in the upper right corner, there is a clock ticking as you see. During the real task, it will tick for 15 minutes and the system will shut down automatically. Also, the computer in front of you has the latest voice recognition software installed so that you don’t need to type your ideas. In other words, unlike other team members who need to type their ideas, you just speak your ideas. The software will do the rest. When you speak into the computer, try not to ramble, speak loudly, speak at a constant rate, and try not to mumble. These are recommended by the software manufacturer.

[Have individuals enter a comment or two into the system on a sample problem.]

Please put on the headset in front of you and make yourself comfortable. While I step out of the room, I would like you to speak a comment into the system. This comment should address the question displayed at the top section of the window – e.g., who will win the 2003 NBA finals?

[Return to the lab in 30 seconds or so.]

[Now state]

When using this type of system, it is often more effective to send many short messages so that you can see what you are thinking rather one long message.
If you have any comments about how to use the system or if you are having
problems with your computer during this experiment, please don’t hesitate to ask me
for help.

OK, do you have any questions? Do you understand how to enter comments into the
system?

Great!

[Give two or three minutes for more practice.]

I will step out of the lab. Practice several more minutes.

[Step into the lab after several minutes.]

[Have participants close the training task browser.]

Experimental Task

[Have internet browser on and ready to go.]

Please go to the URL for the actual task that is given on the cover of your
questionnaire packet.

When you see a small network security window pops up, enter the userid, password,
and domain name in the corresponding boxes as I indicated on the white board and
stand by just like you did with the training task. Please do not hit the “enter” button
unless I ask you to do so.

[Wait until the subject has entered the codes in the security window. Then, describe
the group brainstorming rules and the main task.]

Now, I’d like you to look at the cover of your questionnaire packet. It has the
rules of group brainstorming. When you work on a task to share your ideas with
others, you need to follow these rules.

1. Criticism is ruled out. Withhold your adverse judgment of others’ ideas.
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tame down than to think up.
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useful ideas.
4. Combination and improvement are sought. In addition to contributing ideas of
your own, participants should suggest how ideas of others can be turned into
better ideas or how two or more ideas can be joined into still another idea.
Do you have any questions about the rules of group brainstorming? OK, now let me talk about the real task.

Many students have experienced the frustration of not being able to find a parking space on campus. You are asked to help us resolve the campus parking problem: How can we improve the university’s parking problem? Your ideas will be reviewed and used to improve the parking problem. In this experiment, you will be randomly assigned to a group to solve the problem. You will be given 15 minutes. During this time, please use the computer system for all your group communication.

[Tell participants to click the “OK” button simultaneously.] Please begin working on the task.

[Step out of the lab]

[Step into the lab after 15 minutes] Please fill out the questionnaire.

[Wait for the subjects to finish. If they are done, say the following.] Thank you very much for your participation. For several weeks until I complete the data collection, please do not talk about the experiment you performed in this lab with other subjects who will be participating in later sessions. Again, thank you for your participation. You may leave now.