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A Re-analysis of the Effects of Individual Personality and Idea Stimulation on Idea Generation Performance

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〈Content〉

Ⅰ. Introduction

Porter's competitive forces model (1985) allows us to drive competitive advantages, which refers to the ability to stay ahead of other competitors. Greater innovation effort to meet or exceed customers' needs and expectations seems to be at the core of sustainable competitiveness because innovation leads to more effective products, processes, services, and technologies that are readily available to markets. Nokia has been a good example of what could happen when innovative efforts diminish. Since change is a catalyst for innovation, Jung (2012, 2013b) puts an emphasis on the role of creativity as a foundation to foster successful innovation. Although creativity is often viewed as an abstruse concept, creativity in the problem-solving process (because businesses face many challenges and problems) refers to the capacity to exploit the intellectual capital to generate novel and useful ideas (Luthans,

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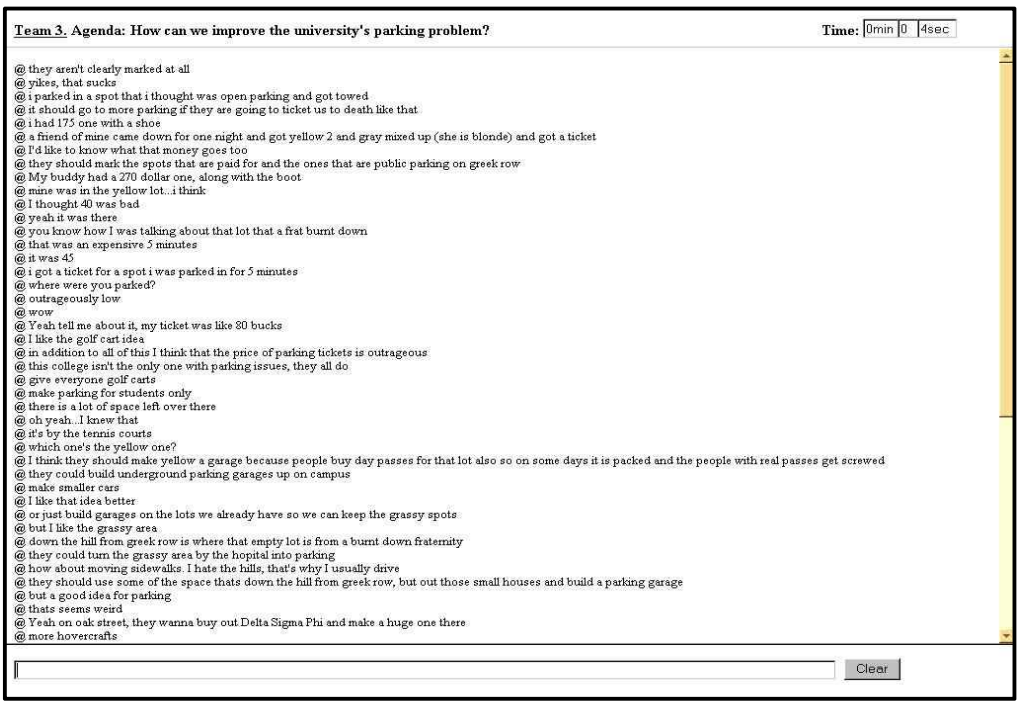
2002). In this sense, divergent thinking, which includes association of remote ideas and pattern switching, has long been considered a major key to creative problem solving (Woodman et al., 1993). Accordingly, substantial research attention has been given to the idea generation task, which promotes the development of divergent thinking because diverse stimulation increases the breadth of idea production and expands the logical size of an idea pool (Valacich et al., 1995), leading to creative, innovative ideas to achieve competitive advantages.

Thus far, numerous techniques have been developed and the computer-based idea generation technique attempts to fully exploit this notion (i.e., divergent thinking) with the support of built-in structural features such as parallel input, group memory, and anonymity. However, despite computer-based idea generation's tendency to facilitate the breadth of information sharing (Miranda and Saunders, 2003), studies (Valacich et al,, 1995, 2006) suggest that group members often do not attend to information they receive, which is a prerequisite to cognitive stimulation and divergent thinking in turn. Hilmer and Dennis (2001) reason that information presented in a large unorganized pool of information (i.e., random display of contributions in a text format) makes individuals difficult to process and integrate information.



<Figure 1> Typical Anonymous Computer-Based Ideation Environment

Additionally, the diversity of information, which quickly accumulates a high volume at a higher rate, induces information overload (Speier et al., 1999). In such an environment, individuals tend to narrow their attention (Hilmer and Dennis, 2001; Speier et al., 1999) by filtering and/or ignoring stimuli. However, the neurological-biological approach of individual differences suggests that extraversion whose cortical arousal is less sensitive (Eysenck, 1982) and whose breadth of attention is chronically wide (Kasof, 1997) is expected to be more tolerant than introversion in computer-mediated idea generation. Based on the notion of neurobiological differences, Jung et al. (2012) conducted two controlled experiments using a group simulator to test whether or not individual differences in the personality characteristic of extraversion/introversion could play a significant role in group idea generation. The results showed that (1) the extraverted individuals performed significantly better than the introverted individuals, indicating that computer-based idea generation appears more productive technique for extraverts, and (2) extraverts generated more unique and diverse ideas than introverts in moderate and high stimuli conditions only.

Through Jung and colleagues' series of studies (e.g., Jung 2012, 2013b), we have learned that the performance behavior tends to become quantity-oriented from quality-oriented toward later stages of the idea generation session. In the early stage, individual's performance behavior was guided by procedural rules, creating a competitive atmosphere. However, as the session progressed, taking advantage of anonymity, individuals in almost all groups exhibited a tendency of self-presentation by capitalizing on ideas of which quality was low and even frivolous (i.e., junk comments). Jung's time interval based analysis (2013b) provides a clearer picture of the tendency of performance behavior from quality to quantity (see table 2 below). Approximately, up to the middle stage from the early stage, individuals' performance behaviors were maintained in good currency. However, toward the later stage of the session, individuals in almost all groups exhibited a tendency of self-presentation by capitalizing on ideas of which quality was low. Thus, the present study re-analyzes Jung 2012's data using the time interval based analysis to examine if the process of idea generation is in good currency throughout the ideation sessions. In this way, the relationship between extraversion-introversion personality trait and ideation performance in the context of computer-mediated idea generation can be better understood. Below we review the relevant literature to motivate our hypotheses.

<Table 1> A Summary Differences between Prior Studies and the Current Study

Jung 2012	None has tested the moderating effect of extraversion-introversion differences on group idea generation performance. Thus, this study measured ideation performance differences between extraversion and introversion.
Jung 2013b	This study analyzed submitted ideas based on time stamps. The purpose is to monitor performance behaviors throughout the ideation stages. In this way, we could properly intervene when performance behaviors deviate.
Current Study	By borrowing the intervention concept from Jung 2013b, the current study attempts to re-analyze the data collected in Jung 2012. Because introverts show a tendency of performance impairment under dual-task interference such as idea generation, we could find out when to inject an intervention technique to boost the performance of introverts.

<Table 2> Number of Ideas Generated per Approximate 3-Minute Intervals by Interactive Five-Member Groups When Given Performance Feedback in a 10-Minute Session

	Time		
	Early Stage	Middle Stage	Later Stage
	0 - 3.2 min (200 sec.)	3.2 - 6.4 min (200 sec.)	6.4 - 10 min (200 sec.)
Quantity*	19.02	18.35	26.13
Quality	58.56	56.32	41.62

Ⅱ. Theoretical Framework

The influence of arousal – a noncognitive variable that alerts a physiological and psychological readiness to respond – on cognitive processes for learning and performance is undeniable. There are theoretical reasons to believe that creativity is related to general level of cortical arousal because Martindale's (1999) review of major theories of creativity suggests that creative people tend to exhibit low levels of cortical activation and of frontal-lobe activation during the process of creative thinking. A substantial body of neuroscience research pinpoints that the (ascending) reticular activating system (RAS) – located in the center of the pons in the human brain and is connected to the cerebral cortex that plays key cognitive functions such as memory, attention, and thinking – is responsible for regulating the level of cortical arousal (Eysenck, 1982). Over

* The performance of idea genearation has been measured by the number of ideas generated and the total quality score of those ideas. See the "idea stimulation manipulation" section and the "dependent variables" section for details.

the past half century, extraversion/introversion personality difference is believed to be a (relatively) highly genetically determined component as the result of biological difference of the RAS (Zuckerman, 1991). Eysenck (1982) further posits that such difference in the RAS significantly influences a person's characteristic level of arousal and, in turn, influences his / her performance in a variety of areas, such as conditioning and sensory threshold (p. 319). With recent advances in brain-scanning technology (e.g., Magnetic Resonance Imaging), which tracks the biochemical processes of the human brain, neuroscientists have confirmed the relationship between the degree of cerebral blood flow in the frontal lobes and extraversion/introversion individual difference (e.g., Johnson et al., 1999). They found that introverted as compared with extraverted individuals had higher blood flow in the frontal lobes and visual cortex even during relaxation. This suggests introverts' tendency to engage in more cortical activities such as thinking and remembering even in the absence of external stimulation. Such higher cortical activities may also reflect their internal and external dispositional anxiousness (Eysenck, 1982). Further findings relate extraverts to have a low sensitivity to Dopamine, a neurotransmitter most closely related to the regulation of higher cognitive functions such as attention and learning and to have a tendency of longer D4DR (or novelty-seeking) gene, which affects the dopamine neurotransmitter (Laney, 2002). Thus, these findings establish a strong linkage between biological differences in arousability and extraversion/introversion.

Eysenck (1997) notes that extraversion/introversion has long been identified as a major dimension of individual difference. Significant differences between extraverts and introverts have been found in a variety of contexts (e.g., Eysenck, 1997; Kasof, 1991; Yellen et al., 1995). Kasof (1997) suggested that "creative ability is related to chronically wide breadth of attention (p.304)" and found that breadth of attention (i.e., the number and range of environmental stimuli attended to at any one time) correlates positively with creativity and performance of novel idea generation. Humans' differences in their attentional levels (e.g., Engle, 2002) can be measured by working (or short-term) memory capacity (Matlin, 2005). Such attentional differences can be partially traced to personality dimensions of extraversion/introversion because extraverts are under-aroused and tend to seek external stimulation, while introverts are over-aroused and tend to avoid external stimulation (Eysenck, 1982). Prior studies (e.g., Lieberman, 2000) that extended the relationship between arousal level and recall performance consistently suggest superior working-memory capacity of extraverts over introverts. In sum, Matthews et al. (2003) summarize that extraverts are better at divided attention, working memory utilization, and retrieval from semantic memory. Thus, the

biological-neurological difference in arousability between extraversion and introversion represents at least one component in predicting individual performance differences in computer-mediated idea generation where information randomness and information overload prevails.

Thus, as mentioned in the introduction section that typically, individuals' performance behaviors were in good currency up to the middle stage approximately and decreased after that, we speculate that extraverts, who tend to be under-aroused and tend to seek external stimulation, will be more tolerable under noise or dual-task environment (e.g., group idea generation – individuals have to handle two or more alternative ideas at the same time (Matlin, 2005)). On the other hand, studies indicated that introverts responded slower than extraverts in the dual-task condition (Eysenck and Eysenck, 1979). In the Test of Attentional and Interpersonal Style, "introverts reported a tendency to make mistakes and become confused, whereas extraverts perceived themselves as being able to integrate many stimuli effectively and to process a great deal of information" (Eysenck, 1982, p. 128), supporting attentional differences. Recent studies further pinpoint that the performance impairment of introverts under noise or dual-task interference is due to their more complex and longer neural pathways associated with central executive functions such as attention and memory in the frontal lobes (Liebermanl, 2000). This leads to the following:

H: Extraverts are expected to maintain the process of idea generation in good currency better than introverts throughout the ideation sessions.

Ⅲ. Methods

3.1 Research Design

	Stimuli Level			
Personality Differences	extraversion 0	extraversion 20	extraversion 40	extraversion 80
	introversion 0	introversion 20	introversion 30	introversion 40

<Figure 2> Research Design

A 2×4 factorial design was used, crossing personality differences (extraversion and introversion) with the degree of stimuli (0, 20, 40, and 80 high-quality ideas). Participants were randomly assigned to one of eight treatment conditions. The group simulator is used to measure individual level performance.

3.2 The Group Simulator

A simulator was designed to accurately control the presentation of ideas in order to control error variance that inevitably occurs in interacting groups (Garfield et al., 2001). As a result, the simulator yielded a more accurate and controlled measure of individual performance. Garfield et al. (2001) describe a group simulator as an electronic environment that "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" (p. 327).

The simulator closely mimicked the sequence of a real, interacting group idea generation session in a way that idea seeds are presented sequentially to the subjects. We typically see a downward linear relationship between the numbers of ideas generated over time within real, interacting group idea generation sessions (Brown and Paulus, 1996). 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. This pattern of idea presentation was controlled via programming within the simulator.

Pilot testing confirmed that the simulator accurately reproduced the sequence and interactions of a real, interacting group idea generation session. Within the experimental sessions that simulate group size five, a post session question asked each participant "How many people do you think you were working with on this task?" On average, participants reported working with 4.76 group members (Standard Deviation = 1.03). Thus, it appears that participants believed that they were working in a real, interacting group.

3.3 Idea Stimulation Manipulation

Prior studies have commonly cited the number of contextual cues as a determinant of information overload (e.g., Speier et al., 1999). To determine high and low load, we followed Grisé and Gallupe's (2000) information overload model. This model suggests 40 ideas to be sufficient to induce information overload in a ten-minute period. This anchors 20 ideas as low load and 80 ideas as extreme high load. In addition, no stimuli (0 ideas) was used as a baseline.

To create three idea streams, an independent coder reviewed a master idea list (containing 457 ideas) that was created from university A in the U.S. and selected 80 geography-neutral high-quality ideas (Mean = 4.69, Standard Deviation = .93). The quality of the ideas on the master list was rated by three senior parking experts on a seven-point Likert scale.

The overall inter-rater reliability of the ratings was .92. Prior research has operationalized "high quality ideas" as those with a quality rating of 3 or higher on a 5-point Likert scale (Jung, 2012). Since a 7-point scale was utilized to evaluate idea quality, ideas with an average rating of 4 or higher were considered high quality. Since the expert raters still considered ideas in the range of 3.0 to 4.0 quality ideas, these ideas were also included to create a sufficient idea pool. From 80 selected ideas, 20 and 40 ideas were randomly selected to serve as low load and high load. 80 ideas were also randomized to serve as extreme high load. These idea streams were then fed into the group simulator to mimic a real, interacting group idea generation session.

3.4 Participants

In a preliminary test, we employed both Goldberg's (1992) personality scale and Francis et al.'s (1992) extraversion scale to identify target subjects. With both scales, extraverts were abundant, but (true) introverts were rare with Goldberg scale. As a result, we switched to Francis et al.'s scale, which is more flexible for a business school setting. 342 undergraduate business students visited a secure web site to respond to Francis et al.'s extraversion items. To create as large difference in personality as possible and to get a sufficient number of introverts, participants who scored 6 as extraverts and participants who score 0, 1 or 2 as introverts were recruited. This method is consistent with other prior studies (e.g., Topi et al., 2002). 75 target participants (38 extraverts and 37 introverts) were invited for hypothesis testing. In return for their time and effort, course credit corresponding to less than one percent of their overall grade was awarded. The average participant age was 25.1 years (Standard Deviation = 7.49), and 52 percent of participants were male.

3.5 Task

Participants 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 – since it stimulates participants to draw on their personal knowledge and experience – and because it has been used in many prior studies (e.g., Garfield et al., 2001).

3.6 Dependant Variables

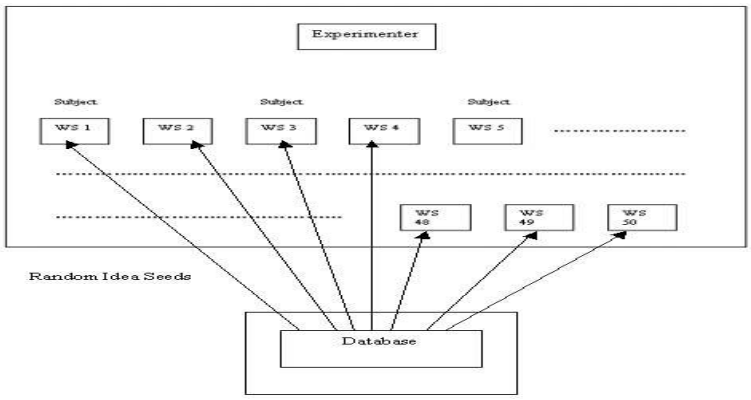
The dependent variables were the number of unique ideas generated by individuals and the exact time stamp when each idea was submitted. The former measure indicates the strength of cognitive stimulation and is consistent with many prior studies (Garfield et al., 2001). In addition, prior studies establish a consistent relationship between quantity (the number of unique ideas) and quality (number of good ideas) (e.g., Valacich et al., 2006) although it was criticized that the performance evaluation of idea generation as "without

regard of quality." The latter measure allows a time interval based analysis to examine the currency of idea generation throughout the ideation session.

To identify the number of unique ideas generated, one coder first analyzed all comments captured by the group simulator. A methodology similar to previous studies was used to avoid duplicate comments (Nijstad et al., 2003): If the subjects' ideas were unique and presented before the stimulus ideas, they were counted. If ideas are the same or very similar to the stimulus ideas, and they were presented after the stimulus, they were not counted. Consistent with prior studies, a second coder then independently analyzed a random subset of transcripts from 19 participants to confirm the initial coder's categorization. The Cronbach's interrater reliability value of .925 indicated the coding was highly consistent.

3.7 Procedures

On reporting to an experimental session, each participant visited a secure website for simulation. Subjects were instructed that they would work randomly with other group members who were remotely located using a web-based groupware system that would allow them to exchange ideas. Subjects were allowed to become familiar with the operation of the simulator prior to the main task by reading an illustration. Then, participants assigned in stimuli conditions were given a version of Osborn's (1957) brainstorming rules and were instructed to follow them. The rules directed subjects to generate as many ideas as possible, to withhold criticism, to include wild ideas, and to build on the ideas of others. Each subject's contributions and idea seeds from the database were anonymous. They were also told that their contributions would be used to improve the campus-parking problem. The simulator was programmed to stop automatically after 10 minutes, after which the subjects completed a brief questionnaire and were then released.



<Figure 3> Experimental Process

IV. Results

Since no significant performance differences between extraverts and introverts were found under no stimuli or extremely high-stimuli conditions, we only test the moderate-stimuli and high-stimuli conditions. Table 3 presents the means and standard deviations for the dependent variable. In table 4, the number of comments submitted and the number of ideas before and after the middle stage of the ideation sessions were analyzed. The hypothesis that extraverts are expected to maintain the process of idea generation in good currency better than introverts throughout the ideation session, was supported. Independent t-tests showed that (1) the number of comments submitted before and after the middle stage for both extraverts and introverts did not differ ($p > .05$), and (2) the number of ideas before and after the middle stage did differ ($p < .05$) for introverts.

<Table 3> Means and Standard Deviation for Number of Unique Ideas

Dependent Variable	Degree of Idea Stimuli	Personality Type	
		Extraversion	Introversion
# of unique ideas	20		
	M (mean)	7.44	3.44
	SD (standard deviation)	2.19	2.07
	40		
	M (mean)	5.54	3.80
	SD (standard deviation)	1.51	2.09

<Table 4> Number of Ideas Generated Before and After 5 Minute Intervals by Interactive Five-Member Groups When Given Performance Feedback in a 10-Minute Session

	Time			
	# of comments before 5 minutes	# of comments after 5 minutes	# of ideas before 5 minutes	# of ideas after 5 minutes
Extraverts				
20 stimuli				
M	5.89	5.89	3.89	3.56
SD	2.93	3.44	1.54	1.01
	Total: 53	Total: 53	Total: 35	Total: 32
40 stimuli				
M	4.36	3.82	2.91	2.64
SD	1.50	2.09	1.04	1.03
	Total: 48	Total: 42	Total: 32	Total: 29
Introverts				
20 stimuli				
M	3.44	3.22	2.56	0.89
SD	1.67	1.92	1.94	0.60
	Total: 31	Total: 29	Total: 23	Total: 8
40 stimuli				
M	3.50	3.40	3.50	3.40
SD	1.58	1.89	1.58	1.89
	Total: 35	Total: 34	Total: 25	Total: 13

V. Discussion

5.1 Research Summaries

In this study, we focused on the issue of the tendency of the lack of attention to stimuli in computer-interacting groups (Hilmer and Dennis, 2001). We argued that the current practice of randomly displaying all contributions in an unorganized text format (although it is intended to facilitate divergent thinking) demands cognitive processing and even challenges individuals' cognitive capacities, reducing the level of cognitive stimulation. We then introduced a neurobiological approach of individual differences, which has demonstrated extraverted as compared with introverted individuals to show a tendency of superior performance at divided attention, working memory utilization, and resistance to distraction (Matthews et al., 2003) in stimulating or stressful conditions, to account for the cognitive stimulation discrepancy.

Our results confirm the pattern of the Yerkes-Dodson model in that the performance of extraverts increases as the level of stimuli increases up to an optimal point (20 ideas in this case) and a further increase in arousal beyond this point decreases performance (40 and 80 ideas in this case) (see figure 5). However, introverts' performances remained unchanged with varying degrees of stimuli. As for the performance comparison between extraverts and introverts, there were no performance differences under the conditions of no arousal (0 ideas in this case) and extreme high arousal (80 ideas in this case) as anticipated. However, under moderate to high arousals (20 and 40 ideas), extraverts performed better than introverts. Additionally, a close examination of the data yields higher performance of extraverts over introverts across all treatments.

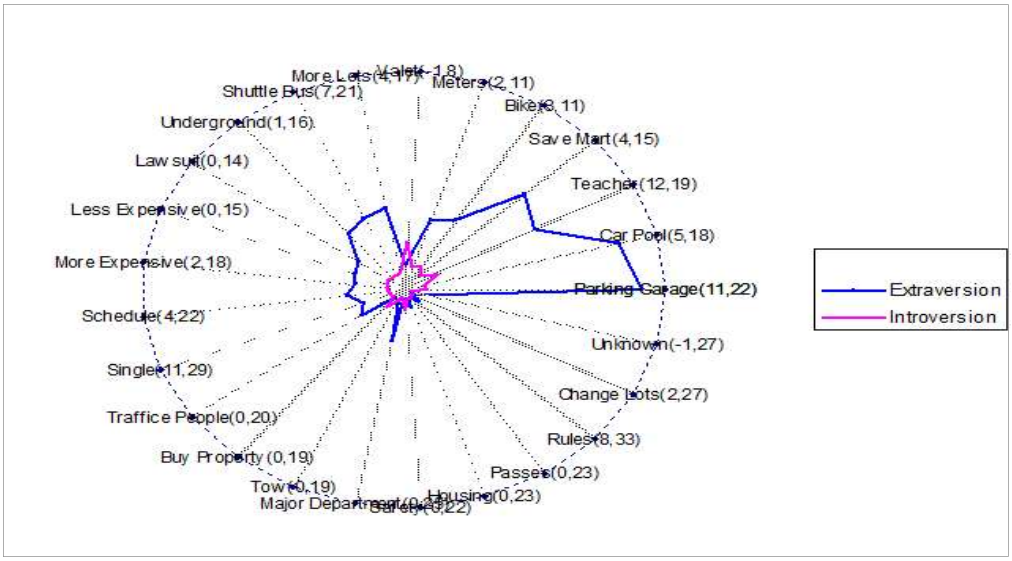
These results are encouraging in that extraversion/introversion individual differences may play an important role in reducing the cognitive stimulation discrepancy in computer-mediated environment. As Grisé and Gallupe's (2000) information overload model suggest that forty ideas in a ten-minute period are sufficient to cause information overload, this suggestion is also consistent with our finding in that extraverts not introverts reflect the pattern of the information overload model. Additionally, this study confirms Eysenck's (1997) view that individual differences may play an important role to account for productivity losses in computer-interacting groups.

Based on the above findings, we tried to further understand why such performance differences occur between extraverts and introverts by analyzing each idea's time stamp. Earlier, we theorized that extraverts, who tend to be under-aroused and tend to seek external stimulation, will be more tolerable under noise or dual-task environment. On the other hand, introverts would respond slower than extraverts in the dual-task condition (Eysenck and

Eysenck, 1979). Recent studies further suggested that the performance impairment of introverts under noise or dual-task interference is due to their more complex and longer neural pathways associated with central executive functions such as attention and memory in the frontal lobes (Lieberman, 2000). Table 4 clearly demonstrates our performance speculation on extraverts and introverts in group idea generation environment: introverts' performances significantly dropped after about the middle stage of the ideation session, whereas extraverts did not seem to feel time constraints throughout the ideation session.

Another interesting finding relates to an optimum size of group. Prior studies (Mullen, 1983) consistently suggest approximately five as the most ideal group size in dealing with intellectual and cognitive tasks including idea generation. With the results in this study that indicate extraverts' decreased performance when given more than 20 stimuli, it appears that approximately 40 ideas is a maximum threshold for extraverts. Since individuals generate on average 10 ideas in a fifteen-minute session (e.g., Valacich et al., 2006), we can estimate that three to five is an optimal group size for extraverts. On the other hand, we speculate that less than twenty stimuli may be a maximum threshold for introverts in interacting groups and estimate that two to three as an optimal group size for introverts.

An additional interesting analysis is to see a holistic picture of "divergent thinking" ability for extraversions and introversions. We categorized all identified ideas and compared the performances on multiple dimensions (see figure 4). The custom radar charts clearly show that extraverts' polygon encompasses that of introverts and the size of polygon is distinctively larger. The interpretation of the graph is straightforward; extraverts appear to have a superior divergent thinking, which is a major key to understand creative productivity in the problem-solving process. Since the result shows that extraverts tend to yield a larger pool of ideas, another interpretation is that group composition with extraverts compared with introverts may create a logically larger group, which is important to improve the performance of idea generation group (e.g., Valacich et al., 1995).



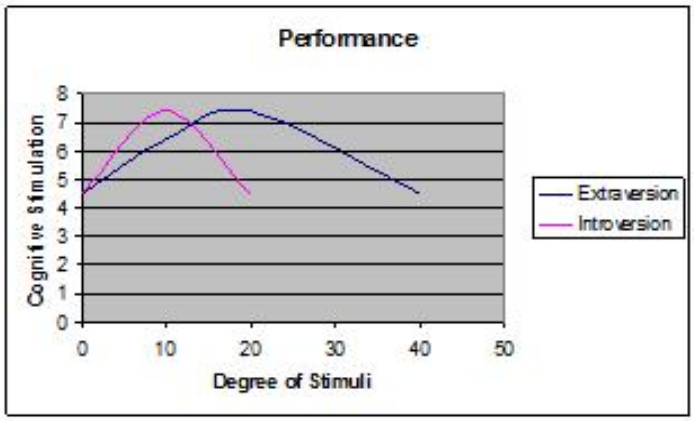
<Figure 4> Categorical Performance Comparison on Multiple Dimensions

5.2 Implications for Research

A follow-up study relates to introverts' performances, which showed no differences across all treatments. We speculate that this is due to the discrepancy in the personality measurement scales used. A measurement comparison of Goldberg's scale and Francis et al.'s scale against participants' responses in the preliminary data showed that all subjects who scored 0, 1, 2, and 3 with Francis et al.'s scale scored somewhere between introversion and extraversion with Goldberg's scale; those who scored 4, 5, and 6 with Francis scale showed no differences with Goldberg scale. Although we recruited subjects that yield as large differences as possible with Francis's scale not to cause any complications, we speculate that this scale difference led to an inconclusive result for introverts. Thus, a replication study with Goldberg's scale is necessary to examine whether or not introverts may yield an inverted-U performance shape within 0 to 20 stimuli range and further stimulation induces negative performance relationship. Figure 5 shows our prediction of introversion and extraversion performance with varying degrees of stimuli.

<Table 5> A Personality Measurement Comparison

	Francis et al. Scale						
	0	1	2	3	4	5	6
Goldberg Scale (M, SD)	32.00 7.82	31.73 10.40	40.33 5.85	38.30 4.19	46.25 7.35	48.81 6.98	50.00 5.71



<Figure 5> Modified Research Model

However, figures 5 represent our view of a pattern of cognitive stimulation when given high-quality idea stimuli only. A typical outcome of group idea generation is a combination of high-quality ideas and frivolous comments (low quality ideas and junk comments). When examining a random subset of transcripts (13 groups) from prior studies, all groups produced some number of frivolous comments. Given that the ratio of junk comments reaches on average 34% (SD 13%) and the proportion of inferior ideas to high-quality ideas was about three to two, these frivolous comments (inferior ideas and junk comments) make up of more than two-thirds of contributions. The occurrences of these frivolous comments are "a human problem more than…a computer problem, the side effect of an on-line social system, rather than of any particular computer system" (Hiltz and Turoff, 1985, p. 685). Jessup and George (1997) suggest that when a group is minimally interdependent (as in group idea generation) and social controls are absent (as in anonymous computer-based groups), negative or dysfunctional outcomes (e.g., frivolous comments) are likely to occur.

Unlike in face-to-face groups where the spoken words are transient and quickly disappear as soon as they are verbalized, all contributions including frivolous comments in computer-based groups are preserved in group memory and are constantly displayed on the computer screen throughout the idea generation session. With the current practice of randomly displaying all contributions on the computer screen, frivolous comments that occur sporadically can be (probabilistically) placed next (or close) to thought-stimulating ideas. As Hilmer and Dennis (2001) suggest that individuals need to exert extra effort to discern and process stimulating ideas for cognitive stimulation if information is presented in a large unorganized pool of information (as in

computer-based groups), frivolous comments may significantly interrupt or distract individuals' flow of cognition (Speier et al., 1999) – refers to the intrapsychic processes that enable the acquisition, storage, transformation, and the use of knowledge – on the primary task that is to generate as many quality ideas as possible. Additionally, individuals in computer-based groups experience information overload (Grisé and Gallupe, 2000). Frivolous comments are one such contributor to information overload (Jung, 2012). Given the fact that frivolous comments tend to outweigh stimulating quality ideas in computer-interacting groups, the critical mass for cognitive stimulation is less likely to occur. Under such a condition, even extraverts' cognitive stimulation may not be significant although their central executive functions are more flexible in suppressing irrelevant information (Lieberman, 2000). Nonetheless, a thorough examination for extraverts and introverts under varying degrees of a combination of quality ideas and frivolous comments is a fruitful implication.

Another avenue for research relates to gender effect on performance. Prior studies (e.g., Valacich et al., 2006) commonly suggest no gender effect in the context of idea generation. However, when it comes to reading matter, Riding and McQuaid (1987) suggest that extraverts are verbalizers and introverts are imagers and report that there were more boys than girls in the poor reader group and more girls than boys among the good readers. We recall one study (Jung, 2013a) that closely examined the effect of verbalization on performance in the context of idea generation. Although his study does not indicate any performance differences based on gender, Riding and McQuaid's (1987) study suggest that personality-based gender may have an effect on ideation performance. Given that due to established gender roles across cultures, girls/women are talkers and boys/men are doers (Gullestad, 2003), this notion can be extended in a way that introverted men are rather poor and slow readers than introverted women.

5.3 Limitations

The first limitation relates to the external validity because we employed a laboratory experiment with simulated artificial groups. However, the purpose of the laboratory experiment is to test a model or theory based on precision. In addition, simulation increases error variance control. Another limitation is our operationalization of idea quality. Prior study (Valacich et al., 2006) reveals that low-quality ideas tend to induce similar quality ideas. Thus, we used high-quality ideas only to control any confounding effects. Nevertheless, it should be further examined in how far the results hold if other measures of idea quality (e.g., medium- and low-quality ideas) are used.

VI. Conclusion

Focusing on the aspect of a neurobiological individual difference (introversion – extraversion), this study confirms the pattern of the Yerkes-Dodson model in that the performance of extraverts increases as the level of stimuli increases up to an optimal point, whereas introverts' performances remained unchanged with varying degrees of stimuli. Furthermore, it also finds that introverts' performances significantly drop after about the middle stage of the ideation session, whereas extraverts don't seem to feel time constraints throughout the ideation session. Although further research is necessary, this study provides valuable insights about how to better utilize the computer-based idea generation technique because group members (in particular, introverts) often do not attend to information they receive, which is a prerequisite to cognitive stimulation and divergent thinking.

Acknowledgement: This work was supported by research grants from the Catholic University of Daegu in 2015.

Appendix

Extraversion-Introversion Personality Measurement Scales

Source: Francis et al. (1992)

Are you a talkative person?	Yes	No
Are you rather lively?	Yes	No
Can you easily get some life into a rather dull party?	Yes	No
Do you tend to keep in the background on social occasions?	Yes	No
Are you mostly quiet when you are with other people?	Yes	No
Do other people think of you as being very lively?	Yes	No

Source: Goldberg (1992)

Very		Moderately		Neither		Moderately		Very	
1	2	3	4	5	6	7	8	9	
Introverted									Extraverted
Unenergetic									Energetic
Silent									Talkative
Timid									Bold
Inactive									Active
Unassertive									Assertive
Unadventurous									Adventurous

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<Abstract>

A Re-analysis of the Effects of Individual Personality and Idea Stimulation on Idea Generation Performance

Joung-Ho Jung

Purpose

This study re-analyzes Jung 2012's data using the time interval based analysis to examine if the process of idea generation is in good currency throughout the ideation sessions. In this way, the relationship between extraversion-introversion personality trait and ideation performance in the context of computer-mediated idea generation can be better understood.

Design/methodology/approach

A 2 × 4 factorial design was used, crossing personality differences (extraversion and introversion) with the degree of stimuli (0, 20, 40, and 80 high-quality ideas). Participants were randomly assigned to one of eight treatment conditions. The group simulator is used to measure individual level performance. The number of unique ideas generated by individuals and the exact time stamp when each idea was submitted were analyzed to compare performances.

Findings

The results show that introverts' performances significantly drops after about the middle stage of the ideation session, whereas extraverts do not seem to feel time constraints throughout the ideation session, resulting in superior divergent thinking, which is a major key to understand creative productivity in the problem-solving process. Since extraverts tend to yield a larger pool of ideas, another interpretation is that group composition with extraverts compared with introverts may create a logically larger group, which is important to improve the performance of idea generation group.

Keyword: brainstorming, creativity, personality, performance

<국문초록>

외향성·내향성 성격 차이가 그룹 아이디어 생산에 미치는 영향에 관한 연구의 재해석

정 종 호

연구목적

컴퓨터 기반의 아이디어 생산 그룹들이 그렇지 않은 그룹들에 비해 여러 면에서 월등한 퍼포먼스를 보여 왔다고 컴퓨터 기반 브레인스토밍 연구들은 주장한다. 하지만 다른 연구들은 컴퓨터 기반 아이디어 생산 중에 발생하는 인지자극 시너지가 노미널 그룹과 비교했을 때 예상치보다 크지 않다고 지적한다. 컴퓨터 환경 하에서는 개인의 성향 차이에 따라 긍정적이고 부정적인 영향력이 다르게 작용한다. 따라서 본 연구는 아이디어가 생산될 때 발생하는 타임 스탬프를 분석하여 개인의 성향 차이가 아이디어 생산과정에서 어떤 영향을 미치는지를 관찰한다.

방법론

외향성/내향성 개인차와 아이디어 자극수위 (0/20/40/80개 아이디어)를 결합한 이원요인계획법을 사용하였다. 각 실험참가자는 무작위로 8개의 실험조건 중 하나에 할당되었다. 그룹시뮬레이터를 이용하여 실험참가자들의 퍼포먼스를 관찰하였다. 데이터베이스에 모아진 아이디어들 가운데 중복되지 않은 아이디어와 각 아이디어의 타임 스템프를 분석에 사용하였다.

결과

실험결과 (1) 내향성 집단은 외향성 집단에 비해 아이디어 세션 중반부 이후 생산성이 현저히 떨어지는 양상을 보인다. (2) 내향성 집단은 외향성 집단에 비해 현저히 적은 범주의 아이디어 생산 양상을 보인다. 따라서 컴퓨터 기반 브레인스토밍은 외향성 집단의 생산성 향상에 더 적합한 방법으로 보여진다.

키워드: 브레인스토밍, 창의성, 개인 성향, 퍼포먼스

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