The Dependent Variable in Research Into the Effects of Creativity Support Systems: Quality *and* Quantity of Ideas[1]

By: Berend Wierenga
Department of Marketing Management
Center for Information Technology in Marketing (C/IT/M)
Rotterdam School of Management
Erasmus University Rotterdam
P.O. BOX 1738
3000 DR Rotterdam
THE NETHERLANDS
bwierenga@fac.fbk.eur.nl

Gerrit H. van Bruggen
Department of Marketing Management
Center for Information Technology in Marketing (C/IT/M)
Rotterdam School of Management
Erasmus University Rotterdam
P.O. BOX 1738
3000 DR Rotterdam
THE NETHERLANDS
gbruggen@fac.fbk.eur.nl

Abstract

Creativity support systems (CSS) aim at enhancing the creativity of users. There is an emerging stream of research in which the effects of CSS on the creative output of respondents are measured. In this research, it is important to make a clear distinction between the dependent variable, creative output, and the independent variable use of CSS. Furthermore, the research design should take the potential effect of other factors on creative output into account, most notably, creative ability as a trait of the respondents.

An experimental study on the value of creativity support systems was recently reported in MIS Quarterly *(Massetti 1996). That study yielded interesting insights with respect to the value of CSS. However, because of the methodology applied in analyzing the data, the study underestimated the effects of CSS on the creative output of decision makers. In this note, Massetti's experiment is positioned in the broader perspective of current research in the area of CSS, and an alternative framework for analyzing the data is proposed.*

Keywords: Cognitive science, decision aids, research methodology, experimental research, statistical methods, research models, user characteristics

ISRL Categories: AC07, AC08, AI01, AI0105, AI06, AI07, GB01

Introduction

Traditionally, decision support systems help decision makers in choosing from a given set of alternative courses of action. However, computer-based tools which are aimed at helping decision makers generate new courses of action and produce new and useful ideas and which can lead to the innovations necessary to keep an organisation competitive in the market place recently have been available. Basically, these tools are meant to enhance the creativity of the user. They have been called creativity support systems (CSS) (Abraham and Boone 1994; Massetti 1996). Several studies have been reported in which the effects of using CSS on the creative output of respondents are examined. Most of these studies have used an

[1]Robert Zmud was the accepting senior editor for this paper.

experimental approach (Elam and Mead 1990; MacCrimmon and Wagner 1994; Marakas and Elam 1997; Proctor 1988; Rouse 1989; Winship 1991).

A recent example of such an experimental study appeared in this journal (Massetti 1996). That paper is an interesting contribution to the body of knowledge on the effects of CSS and has several strengths. A theoretical model is developed containing the various factors (apart from CSS technology) which may influence the creative performance of an individual. The model is based upon a profound analysis of the creativity literature. Furthermore, a creative idea is developed to prevent a "Hawthorne-effect" by introducing a non-CSS computer treatment in the form of Harvard Graphics. The CSS treatments involved the use of a computer and, because of the approach, it was possible to separate the CSS effect from the computer effect.

Despite the careful approach and powerful experimental setup of the study, we think that—because of the manner of dealing with dependent and independent variables and the methodology applied in analyzing the data—the effect of the creativity support software on the creative output of the respondents was underestimated. The basic problem of the paper concerns the operationalization of the dependent variable creative performance. Creative performance has a quantitative (number of ideas) *and* a qualitative (quality of ideas) component. Both can be positively affected by the use of CSS. In the study, Massetti confuses a quantitive output measure (number of ideas generated by respondents) with a personality trait (fluency) and, in doing so, hides an important part of the effects of interest. Not only does this lead to ignoring the impact of CSS on the quantitative creativity component, it also causes an underestimation of the effect of CSS on the qualitative measures of creativity.

In this research note, Massetti's research design and method of analyzing the data are briefly described. The issue of idea fluency as a creativity trait versus number of ideas as creative output are discussed and the loss of information due to the chosen methodology of analysis is examined. A proposal for an alternative analysis procedure and the (probable) consequences for the conclusions of the study are presented. The note ends with a few ideas for future research on computer-facilitated creativity.

Research Design and Data Analysis

Massetti uses an experiment to study the effects of two different CSS: a *generative* CSS, which especially supports the processes of divergent thinking and remote associations, and an *explorative* CSS, which, rather than offering generic ideas, has the purpose to "embellish, emphasize and polish ideas." (More information about the actual software packages used can be found in the Massetti paper.) In addition to these two treatments, a "pen and paper" treatment (in which respondents used no software at all) and a Harvard Graphics treatment (in which respondents used the standard Harvard Graphics software) were used. The latter two treatments can be seen as controls: the pen and pencil mode for the effect of no software at all versus the use of software and the Harvard Graphics treatment to examine the effect of "general" versus CSS software, i.e., with the specific purpose of enhancing creativity. Respondents were asked to come up with creative solutions for the homeless problem faced by cities and society. Massetti used a 1*4 between-respondents experimental design. The respondents, 43 MBA students, were each assigned to one of the four treatments: the use of pen and paper, Harvard Graphics, generative CSS, and explorative CSS respectively. A pretest creativity inventory scale was administered to the respondents to determine each subject's ability to perform creatively. The creative output per respondent was measured quantitatively by counting the *number of ideas* generated and qualitatively by having (internally reasonably consistent) judges rate the output on *idea novelty* and *idea value* scales. Also, for each respondent, the average of the scores on nov-

elty and value were computed and designated as *"creative performance."*

The analysis first checked whether or not significant differences existed between the treatment groups with respect to creative ability, as measured by the creativity inventory scale. This was not the case, so it could be concluded that the four groups did not differ in terms of creative ability. Then, in the process of testing the first hypothesis (whether or not there are effects of treatments on the number of ideas generated), a confusing step is taken. After having concluded that the variance of number of ideas is not homogeneous over the treatment groups and that the distribution of this variable is bimodal, Massetti concludes that number of ideas ("idea fluency") is an element of creative ability. From that point on, the author considers number of ideas (idea fluency) as a "relatively constant" personality characteristic. So, in the analysis, number of ideas switches from being a dependent to being an independent variable. (Two pages earlier, idea fluency had been mentioned as one of the operationalizations of the dependent variable creative performance, together with idea novelty and idea value.) We will discuss whether number of ideas (and the related construct "idea fluency") should be considered as a dependent or an independent variable in the next section.

Creativity, Idea Fluency, and Number of Ideas

A distinction can be made between two major definitions and conceptions of creativity: *creativity as a trait* and *creativity as an achievement* (Eysenck 1994). Creativity as a trait is a dispositional variable characteristic of a person, leading to the production of acts, items, and instances of novelty. With creativity as achievement, we mean the creative product, the output of a process; for example, the creative performance in the assignment given to the respondents in Massetti's experiment. Creative achievement may depend on the trait of creativity, but also on much more. The following variables have been mentioned as affecting creativity as achievement: cognitive variables (intelligence, knowledge, skills, etc), environmental variables (cultural factors, socio-economic factors), and personality variables (motivation, confidence and *creativity as a trait*) (Eysenck 1994, p. 209). In a study on factors affecting the creativity of marketing programs, three classes of influencing factors were distinguished: problem-solving inputs, situational factors, and motivational factor (Andrews and Smith 1996). These factors coincide to a large extent with Eysenck's variables.

As generally accepted in CSS research, Massetti introduces the availability of a creativity support system as a separate and additional independent factor. If we want to determine the effect of this factor on creative achievement (or "creative performance"), it has to be established that this effect is not due to differences in creativity as a trait (as a personality variable) between the respondents in the various experimental groups. For that purpose, Massetti correctly tested whether differences in creative ability between CSS treatment groups existed. For this test, she used a 36 item scale called "Personal Barriers to Creative Thought and Innovative Action" from the management literature (Hellriegel and Slocum 1992, pp. 237–38). No significant differences were found, implying that eventual differences in creative performance could be attributed to the experimental manipulation and were not due to initial differences in the creative ability of the experimental subjects.

It is important to study the role of idea fluency in this respect. When the psychological literature on creativity as a trait and its measurement are examined, it can be observed that as early as in the 1920s Spearman used the construct of "fluency." Verbal and imaginative fluency were seen as basic for creativity and fluency or "f" tests were developed, some of them including the number of things seen in an inkblot, numbers of words written, numbers of different completions to an incomplete picture and so forth (Eysenck 1994, p. 202). The widely used Torrance Tests of Creative Thinking (TTCT) has fluency as one of its dimensions, besides flexiblity, originality and elaboration

(Cramond 1995; Torrance 1988). So Massetti is right in her observation that (idea) fluency can be considered as a creative ability construct. It would have been perfectly acceptable (maybe even recommendable) if Massetti would have used the TTCT to establish the creative ablitity of her respondents. In that case, she would have obtained measurements for fluency as a dimension of creativity as a trait. However, it is not correct to use the number of ideas produced by the respondents in the experiment as their fluency in the sense of the psychological construct with that name. The number of ideas is the creative output of a process and, as we have seen, it is affected by several factors, including the experimental treatment (i.e., the effect of creativity support software). Quantity of ideas is a separate output variable that should be distinguished from fluency as a dimension of creativity as a trait. Torrance also uses fluency as a creativity trait *and* quantity of creative output as separate entities. In a major study, he found a product-moment correlation coefficient between the two of 0.30 (Torrance 1988, p. 59) showing that, besides the trait, several other factors affect creative achievement.

In the creativity support literature, it is a well accepted approach to consider the number of ideas as a dependent instead of as an independent variable. Eight studies were surveyed in which attempts were made to make respondents more creative by means of support systems (MacCrimmon and Wagner 1994). The conclusion was that number of ideas is the most common measurement of creative output: "Virtually all studies agree on the measurement of the outcome of the decision process in terms of number of ideas" (p. 1524). MacCrimmon and Wagner conclude that usually creative output is considered along two dimensions: quantity (number) and quality of ideas; in fact, the same way as the Massetti paper started out.

Summarizing this discussion, we call for a clear distinction between the measurement of creativity as a trait and creativity as achievement. This way, the precise influence of an experimental manipulation on creative achievement can be determined.

Loss of Information

Besides the fact that quantity of ideas is too interesting a quantitative output variable to omit, it is likely that the data analysis procedure followed by Massetti also removed an important part of the effects of the CSS on the qualitative measurements of creative output: novelty, value, and (the compository variable) "creative performance." Although differences in the variance of number of ideas between the treatment groups may exist (see Table 1), this in no way can lead to the conclusion that the respondents in the treatment groups differ systematically with respect to creativity as a trait. This is confirmed by the negative outcome of test on differences between the groups according to the creativity inventory test. (Of course, a stronger test would have been the TTCT.) Our conclusion is that the difference in the distribution of the number of ideas is a treatment effect rather than the result of an heterogeneous distribution of individuals across groups. Table 1 clearly shows that the number of ideas increases as we go from pen and pencil to software and from general purpose software (Harvard Graphics) to creativity support systems. The number of ideas generated by users of both the generative ($t = 2.08$, $p < .03$) and the exploratory ($t = 2.96$, $p < .01$) significantly exceeds the number of ideas as generated by the control group. Contrary to the conclusion in her paper, Massetti's Hypothesis 1 (use of ICSS technology will result in a greater number of ideas) is confirmed. The presence of a significant relationship between the experimental treatment (use/non-use of CSS) and the number of generated ideas means that it is dangerous to change number of ideas into an independent factor (see Tabachnick and Fidell 1989, p. 322). Transforming number of ideas from a dependent to an independent variable will absorb part of the influence of the treatment on the idea quality variables (novelty and value) and consequently derogate the effects of the availability of the CSS. In the Massetti study, this clearly has been the case. From the F-values in the paper it can be seen that the relationship between number of ideas and idea quality is very strong.

Table 1. Distribution of Number of Ideas Over Treatment Groups in the Massetti (1996) Study

Treatment Group	n	Average Number of Ideas	Respondents with a High (H) or Low (L) Number of Ideas[2]	
Pen and Paper	9	2.22 (1.13)[1]	H=2	L=7
Harvard Graphics	12	3.25 (1.48)	H=4	L=8
Generative CSS	11	3.73 (2.53)	H=5	L=6
Exploratory CSS	11	3.91 (1.44)	H=6	L=5

[1]Number in brackets is standard deviation of number of ideas.
[2]H means more than 4 and L means less than 4 ideas.

Proposal for Alternative Analysis

The design of the experiment is straightforward and the same could apply for the method of analysis. A 1*4 experimental design (four treatment classes) with multivariate measurements is set up. The measurements vector is either three-dimensional (number of ideas, novelty, value) or two-dimensional (number of ideas, and "creative performance"). We propose to carry out a multivariate analysis (MANOVA) with number of ideas as an element of the *dependent* variables vector. A multivariate analysis of variance takes into account the relationship between number of ideas and idea quality. The violation of the homogeneity of variance assumption could be raised as an issue, but Tabachnick and Fidell (1989, p. 324) state that the analysis shows robustness to the violation of this assumption as long as there are no outliers. To be on the safe side, before carrying out the MANOVA, a correction for non-normality, as suggested by Tabachnick and Fidell, might be applied. An alternative is to conduct the analysis also in a nonparametric version, i.e., with the 43 observations replaced by their rank numbers. A more elaborate alternative is to carry out a fully non-parametric multivariate analysis (Puri and Sen 1971).

Some Implications for Research on Computer-Facilitated Creativity

In many problem-solving and decision-making situations, creativity is as important as analytical reasoning. Therefore, it is fortunate that software is being developed to support creative decision making and that experiments, such as in the work of Massetti, are carried out to examine the contributions of such creativity support systems to creative output. There is agreement in both the CSS literature and in the psychological literature on creativity that creative output has both a quantitative (number of ideas) and a qualitative (novelty or value) component. Therefore, in effectiveness studies of CSS, both aspects should be measured as dependent variables. Creative output should be distinguished from creativity as a trait, of which, among others, fluency is a dimension. Since respondents may have different creative abilities, creativity as a trait should definitely be taken into account in designing experiments. One possiblity is to adopt within-respondent designs for measuring the (net) effects of different CSS (MacCrimmon and Wagner 1994). Another possibilty is to control for differences in creativity as a trait by using it as a co-variate in the analysis. In that case, creativity as a trait has to be measured. Of course, we may expect

that the differences between experimental conditions, with respect to creative abilities, will also disappear when the number of subjects per treatment group increases after a random assignment.

To make the studies on the effectiveness of CSS comparable, it is recommended that researchers use the same test battery for determining creativity as a trait. The Torrance Test for Creative Thinking seems to be a good option. However, a great many alternatives exist (Eysenck 1994) and it would require a separate study to determine the most suitable creativity test for the context of creativity support systems. In order to prevent every researcher developing their own test, it is important, for progress in this domain, that such a study is undertaken.

Along with avoiding problems in the analyis of the data, a clear distinction between creativity as a trait (i.e., one of the input variables) and creativity as achievement (i.e., output) makes it possible to more thoroughly study the precise effects of CSS on the creativity of its users. Interesting questions in this respect are whether a CSS compensates for a lack of creative abilities (as a trait) of decision makers, whether it reinforces existing creative abilities or whether decision makers that are low and high on creativity can benefit equally. So far, most studies on CSS were so-called factor studies looking at the effects of experimental manipulations but neglecting the black-box between cause and effect. Future studies should should take a process approach to help us understand *how* CSS affect decision-making processes and the various dimensions of creativity.

References

Abraham, T., and Boone, L. W. "Computer-Based Systems and Organizational Decision Making: An Architecture to Support Organizational Innovation," *Creativity Research Journal*, April/May 1994, pp. 111–123.

Andrews, J., and Smith, D. C. "In Search of the Marketing Imagination: Factors Affecting the Creativity of Marketing Programs for Mature Products," *Journal of Marketing Research* (33), May 1996, pp. 174–187.

Cramond, B. "The Torrance Tests of Creative Thinking: From Design Through Establishment of Predictive Validity," in *Beyond Terman: Contemporary Studies of Giftedness and Talent*, R. F. Subotnik and K. D. Arnold (eds.), Ablex Publishing Company, Norwood, NJ, 1995, pp. 229–254

Elam, J .J., and Mead, M. "Can Software Influence Creativity?" *Information Systems Research* (1:1), March 1990, pp. 1–22.

Eysenck, H. J. "The Measurement of Creativity," in *Dimensions of Creativity*, M. A. Boden (ed), MIT Press, Cambridge, MA, 1994, pp. 199–242.

Hellriegel, D., and Slocum Jr., J. W. *Management*, 6th ed., Addison-Wesley, Reading, MA, 1992.

MacCrimmon, K. R., and Wagner, C. "Stimulating Ideas Through Creativity Software," *Management Science* (40:11), 1994, pp. 1514–1532.

Marakas, G. M., and Elam, J. J. "Creativity Enhancement in Problem-Solving: Through Software or Process?" *Management Science* (43:8), 1997.

Massetti, B. "An Empirical Examination of the Value of Creativity Support Systems on Idea Generation," *MIS Quarterly* (20:1), March 1996, pp. 83–97.

Proctor, T. "Experiments with Two Computer Assisted Creative Problem Solving Aids," *Omega* (17:2), 1988, pp. 197–200.

Puri, M. L., and Sen, P. K. *Nonparametric Methods in Multivariate Analysis*, Wiley, New York, 1971.

Rouse, N. E. "Brainstorming Software Unlocks Creativity," *Machine Design*, October 12, 1989, pp. 100–102.

Tabachnick, B. G., and Fidell, L.S. *Using Multivariate Statistics*, Harper & Row Publishers, New York, 1989.

Torrance, E. P. "The Nature of Creativity as Manifest in its Testing," in *The Nature of Creativity*, R. J. Sternberg (ed.), Cambridge University Press, Cambridge, UK,1988, pp. 43–75.

Winship, S. "Packages Stimulate Creative Process, Buyers Say," *PC Week* (23:1), March 1991, pp. 109–110.

About the Authors

Berend Wierenga is professor of marketing at the Rotterdam School of Management of the Erasmus University Rotterdam. He has done research in several domains of marketing with marketing management support systems as his most dominant current area of interest. His work has appeared in international journals such as *Journal of Marketing Research, Journal of Marketing, International Journal of Research in Marketing, Decision Support Systems, European Journal of Operational Research, Management Science* (forthcoming) and *Communications of the ACM.*

Gerrit H. van Bruggen is assistant professor of marketing at the Rotterdam School of Management of the Erasmus University of Rotterdam. His main research interests are in the field of marketing and information Technology. Outlets for his work are journals such as *International Journal of Research in Marketing, Journal of Marketing,* and *Management Science* (forthcoming).