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Testing Einstein's faux formula: fast computers + slow humans = creative brilliance

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An experiment was designed for the purpose of testing the proposition that creative decision-making can be greatly improved by making use of the personal computer to solve a set of word anagrams serving as hints to a surprise phrase. The authors hypothesised that the experimental condition of students using various unscramble word jumble websites would significantly outperform the control group of students who attempted to unscramble the words and solve the surprise answer by hand. Results were mixed and the authors conclude that certain types of creative problem solving exercises might benefit more from the innate abilities and talents of the participants rather than the speed and accuracy of the computer.

Keywords: computing; creative decision-making; word anagrams

1. Introduction: Einstein's faux quote

Albert Einstein is alleged by a number of websites to have said, 'Computers are incredibly fast, accurate, and stupid. Human beings are incredibly slow, inaccurate, and brilliant. Together they are powerful beyond imagination.'[1] The only problem with this attribution is that it has no foundation. There are no references to scholarly articles, books or even speeches proving that Einstein ever said it. Conversely, in the late 1960s two systems engineers studying control systems in a production process wrote, 'Computers are incredibly fast, accurate and stupid. On the other hand, a well-trained operator as compared with a computer is incredibly slow, inaccurate and brilliant.' The authors do not speculate what happens when the two are placed together other than to note that the combination may result in an 'intelligent override' of the 'control system' (Couture and Keyes 1969).

Still, the quote is intriguing and may or may not have reflected Einstein's view but does in fact reflect a point of focus for numerous researchers regarding how computing technology might be harnessed in support of human creativity (Proctor 1989, Schmitt and Brown 2001, Shneiderman 2007). As Shneiderman (2007, p. 22) states:

> During the past half-century, computing professionals have developed potent productivity support tools that reduced manufacturing costs, tightened supply chains, and strengthened financial management. These business productivity support tools were designed to meet clear requirements such as improving insurance claim processing, reducing costs for airline reservations, or simplifying order entry. These tools were conveniently evaluated by standard measures such as time per task, cost per transaction, and errors per order. But now, a growing community of innovative tool designers and user interface visionaries is addressing a greater challenge and moving from the comparatively safe territory of productivity support tools to the more risky frontier of creativity support tools.

2. Introducing computing technology into the creative process

The topic of human creativity has long been of interest to researchers. Finke *et al.* (1992) and Smith *et al.* (1995) developed the Geneplore Model to frame the processes involved in creativity informed by cognitive science. The model identifies two, potentially iterative, phases of the creative process: generative processes and preinventive exploratory processes. The generative processes include knowledge retrieval, association, and mental transformation.

Ward (2004) and Baron and Ward (2004) asserted that specific cognitive abilities may unravel the mystery of why some creative entrepreneurs are successful. Baron and Ward cited these cognitions as:

- 'accurate retention and processing of information'
- 'accurate decision making'
- 'an ability to switch back and forth between heuristic and systematic processing as the need arises'
- (perhaps) 'rapid processing time (as indexed by reaction time)'.

(Baron and Ward 2004, p. 569)

Baer and Oldham (2006) explored the notion of time pressure as a factor in human creativity. They found that 'intermediate' creative time pressure promoted creative output in comparison with conditions of lesser or greater time

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pressure (Baer and Oldham 2006, p. 968). They also found that support for creative activity enhanced the creative output of their subjects. We wish to consider information technology as an aspect of such support for creative activity.

Throughout the past two decades, researchers have begun exploring how to introduce computing technology into the creative process. Some researchers have explored the interface between the field of creativity and the field of information technology. Works by authors like Campbell (1960), Newell and Simon (1972), and Csikszentmihalyi (1990) look at the idea of creativity and express models for how to understand it. Csikszentmihalyi's model adopted a systems approach, defining creativity as 'an interaction between the domain, the person, and the field'. According to Dewett (2003, pp. 169–170):

> Building on the work of earlier theorists (Wallas 1926, Dunker 1945, Rogers 1954, Campbell 1960, Newell and Simon 1972, Amabile 1996) suggested that the three main components of creative performance are domain-relevant skills, creativity relevant processes, and task motivation. Domain relevant skills comprise the individual's complete set of response possibilities from which a new response is to be synthesized, and the information against which the new response is to be judged. Creativity-relevant processes determine the degree to which one's response will surpass previous products or responses in the domain. This component starts with a particular cognitive style characterized by an ability to understand complexity and to break set during problem solving, and also includes knowledge of heuristics for generating ideas as well as a work style conducive to creative production. Finally, task motivation refers to one's attitude toward a task and perception concerning why the task is being engaged. (Amabile 1996)

The Computer Science and Telecommunications Board (2003, p. 34) expressed Csikszentmihalyi's model in Chapter 13, the systems view chapter of the book, *The Nature of Creativity: Contemporary Psychological Perspectives* (Sternberg, Ed., 2003). We drew our own illustration based on Figure 1 showing the interrelationships influencing creative development.

This notion of domain-relevant skills becomes a focal point for the research reported here. Specifically, the authors expected that harnessing computing and web technologies would expand the domain-relevant skills available to students, thereby enhancing their creative performance on a specific exercise as suggested by Ben-Zvi in his article, 'Using Business Games in Teaching DSS' (2007).

The struggle to enhance creativity through technology is best summed up by the Computer Science and Telecommunications Board (CSTB):

> Perhaps the strongest claim is that IT can foster practices that are creative in the most rigorous sense – scholarly, scientific, technological, design, and artistic practices that produce valuable results in ways that might be explained in retrospect but could not have been predicted. At this point, one might detect a whiff of paradox – a variant on Plato's famous *Meno* paradox. Unless it offers users a means to produce something they already know they want, IT is not helpful. But if someone produces something merely by running a program, the production process is predetermined and potentially standardized, so how can the result be truly creative? (CSTB 2003, p. 16)

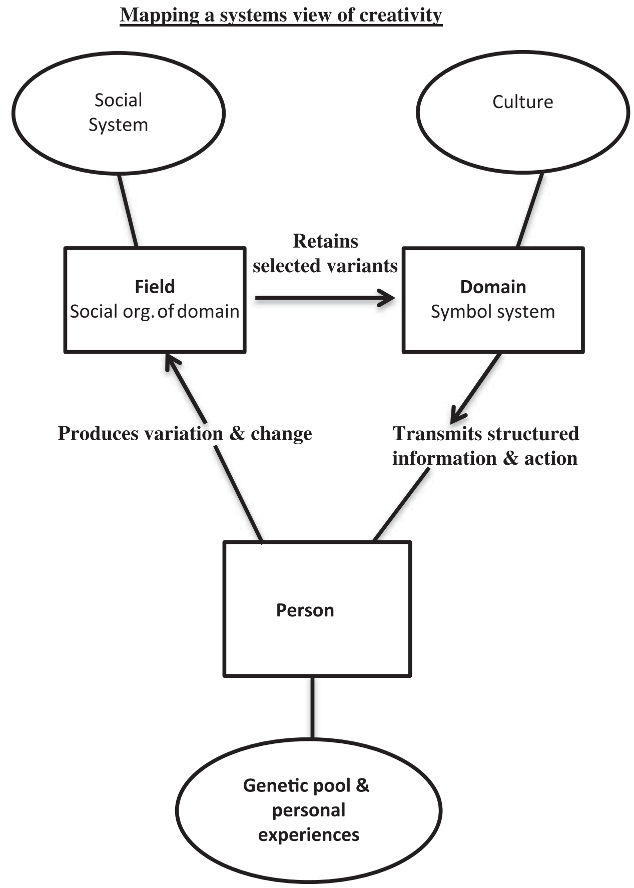

Figure 1. A systems view of creativity. This map shows the interrelationships of the three systems that jointly determine the development of a creative idea, object, or action. The individual takes information provided by the culture and transforms it, and if the change is deemed valuable by a field, it will be included in the domain, thus providing a new starting point for the next generation of creative persons. The actions of all three systems are necessary for creativity to occur.
Source: Derived from Csikszentmihalyi (1987).

3. The development of a hypothesis

In light of the above, the authors designed an experiment to at least reify if not prove Einstein's faux quote. Specifically, it was posited based on earlier research by Dunphy and Milbourne (2009) that students would benefit from using the school's computing resources for the purpose of solving a simple word scramble anagram and that the personal computer would greatly reduce the time needed to unscramble the anagram in comparison to the traditional, pen and paper approach. For example, the anagram 'The Apple MacIntosh' can be turned into the surprise answer, 'Machines apt to help' or, a more basic switch can occur with 'debit card' becoming 'bad credit'.

The hypothesis was that students in the experimental condition directed to use the computer in conjunction with the websites anagram unscramble (http://www.specialist-online-dictionary.com/word-unscrambler.html) and unscramble.net (http://www.unscramble.net) would significantly outperform the control group in terms of words unscrambled, time taken to unscramble as well as ultimate success in solving the overall surprise phrase. The alternative hypothesis is that no such significant differences will be found.

One can view the application of computing and web resources for unscrambling anagrams as representative of Amabile's domain-relevant skills component of creativity described above. The use of web resources to expand the domain-relevant skills of the students involved in the anagram activity is also considered a popular approach for enhancing the creative process. Shneiderman (2007, p. 23) stated that:

> …we already know that an accelerator for creative efforts is the capacity to locate, study, review, and revise existing projects and performances, such as open source software modules, Web page source code, architectural drawings, or music scores. The Web has done much to make existing projects and performances accessible and search engines like Google have helped innovators to quickly find what they want.

With this as background, the authors developed an experiment for studying these notions of domain-relevant skills for students involved in a generic exercise involving creativity.

3.1. The hypotheses

The authors received human subjects' committee approval to test the following three hypotheses:

> H_1: *An experimental group using a computer program will be able to solve significantly more word puzzles than a control group attempting to complete the task using pen and paper.*
>
> H_2: *The time taken to complete the task will be significantly less for the experimental group when compared to the control group.*
>
> H_3: *When looking at the surprise answers only, the experimental group will be able to solve significantly more answers than the control group.*

This research was based on an article proposing just such a study recently published by *Journal of Information Systems Education* (Dunphy and Milbourne 2009). The article included four word anagrams and suggested that the solution of the anagrams would demonstrate the productive use of the personal computer. The clue phrases and overall surprise answers are given in Table 1.

3.2. The experimental design

The first two exercises were used in the control condition. The second two exercises were used in the experimental condition and the authors believed that all anagrams were similar in terms of their level of difficulty. The experimental anagrams were perhaps even more difficult than the control anagrams due to the fact that they contained more two syllable scrambled clue words.

Following the guidance of the Campus Institutional Review Board, students in an introductory computing class were offered the opportunity to participate in the experiment. Those that elected not to participate were offered an alternative exercise. All students were offered the opportunity to earn class homework credit through their chosen activity. All but one student offered the opportunity to participate in the experiment ultimately did so.

The experimental activity was administered by a teaching assistant without the presence of a faculty investigator in order to remove potential bias or influence by the faculty member. At the end of one classroom session early in the semester, students were randomly assigned to either the control or experimental group by the teaching assistant. Depending on the student's assignment, they were either encouraged to employ web-based de-scrambling utilities, or they were prevented from doing so. The teaching assistant recorded the duration of time between providing the assignment handout and receiving the completed handout back from each student. The handouts were returned anonymously by each student participant; no connection was made between a given experimental performance (as expressed by the handout) and the student. Students were awarded homework credit for simply participating in the exercise.

The faculty investigator then 'graded' the submitted handouts for correctly unscrambling the anagrams and for solution of the surprise phrases. Data were collected about how many anagrams were correctly unscrambled and how

Table 1. Clue phrases and surprise answers.

Number	Control group or experimental group?	Clue	Answer
1	Control	*The third pig of yesteryear was a survivor. Todays IS entrepreneur might do even better by combining this with that…*	'Clicks and bricks'
2	Control	*America's homemakers have traditionally been served by businesses located from sea to shining sea but now they are being served both by this and that.*	'C to c and b to c'
3	Experimental	*While businesses say they have great interest in improving their products and services, they actually seem more interested in improving this…*	'The bottom line'
4	Experimental	*Clairvoyants work wonders using E.S.P. What homeowners might use to travel to cyberspace (thereby neglecting both time and place)*	Internet Service Providers

many surprise phrases were solved. Length of time for solution, as recorded by the teaching assistant during the exercise, was then connected to the solution performance using anonymous codes.

Students had never been exposed in class to the websites anagram unscramble (http://www.specialist-online-dictionary.com/word-unscrambler.html) and unscramble.net (http://www.unscramble.net), so the authors believed that it would take experimental condition students some time to navigate the websites. The authors further believed that the time taken accessing, navigating and typing words in to the websites might offset the fact that the computer was being used as a decision aid rendering both control and experimental conditions equal in terms of time needed to solve the anagrams.

Regarding the timing process and the collection of data, the following methodology was followed:

(1) The facilitator explained the directions to all the students in class.
(2) The facilitator randomly distributed the exercise handouts, instructing students not to turn over the cover page until told to.
(3) The facilitator then announced it was time to start, meaning students could turn their cover page over and begin their work. He then recorded the time when everyone was asked to start.
(4) As students returned their papers to the facilitator, he recorded the time of submission down to the second on the cover sheet of the handout.

The Primary Investigators simply subtracted the start time from each student's end time to calculate the time spent trying to solve the anagrams.

4. Results

It was hypothesised that those students who used the computer as an aid for unscrambling the anagrams would solve a significantly higher number of anagrams and surprise phrases than those students who attempted to unscramble the anagrams using pen and paper. To test this hypothesis, the authors compared the mean scores for these two groups by letting μ_1 is the population mean score for the quiz in the experimental group, while μ_2 is the population mean score for the quiz in the control group. Thus, the hypothesis can be rewritten as follows:

$$H_0 : \mu_1 - \mu_2 < 0,$$
$$H_a : \mu_1 - \mu_2 > 0.$$

Using the one way t-test for differences the null hypothesis (H_0) of lower scores for the experimental versus control groups is rejected at $p < 0.001$ with a t-value of 6.4, an overall standard deviation of 19.1 and degrees of freedom of 61. The alternative hypothesis of higher scores for the experimental group is accepted. Results are reported in Table 2.

These results seem especially robust. The range of the scores jump from 0–80 (out of a potential perfect score of 100) for the control group to 72.7–100 for the experimental group. The authors believe that the use of the computer as an aid may be especially important for those students who are unable to solve any word scrambles. The authors speculate that a number of students in the control group may have become frustrated with the difficulty of the task and may have lost motivation especially if they were unable to solve any word scrambles scoring 'zero' on the exercise. This belief is an educated guess, and not a proven phenomenon. On the other hand, all students in the experimental group were able to solve a minimum of four word scrambles using the computer as an aid. Hence, the control group has a relatively large standard deviation of 25.1 due mainly to the number of 'zero scores' previously mentioned. The experimental group has a relatively small standard deviation of 7.34 because the computer program enabled virtually everyone to solve at least some of the anagrams hence the data set contains no 'zero' scores. The authors believe that the students in the experimental group were more highly motivated and more satisfied with the exercise since they were able to use the computer as a learning aid but this is pure speculation and no effort was made to measure motivation or satisfaction with the task.

Furthermore, based on data collected concerning student time on task (four classes), it was concluded that the time taken for students who used the computer as an aid

Table 2. Results of t-test and descriptive statistics for percentage of anagrams solved, experimental vs. control groups.

	Percent of anagrams solved								
	Experimental group			Control group					
	M	SD	n	M	SD	n	95% CI for mean difference	t	df
Scores	84.6	7.34	29	53.5	25.1	34	23.03–39.17	6.44***	61
Range	72.7–100			0–80					

Note: Independent samples t-test. A Cohen's $d$value was calculated for the size of the effect. Cohen's effect size value ($d = 1.68$) suggests a high practical significance.
$^{***}p < 0.001$.

Table 3. Completion times of anagrams solved, experimental vs. control groups.

	Number of minutes until completion or abandonment								
	Experimental group			Control group					
	M	SD	*n*	*M*	SD	*n*	Mean difference	*t*	df
Scores	15.1	4.03	29	14.9	3.43	34	.2 min	.228	61
Range	9.0–25.5			8.0–19.9					

Note: Independent samples t-test. $p \leq .82$ (nonsignificant).

to unscramble their anagrams was NOT significantly less than the time taken for those who did not have access to the computer. In running this exercise over the years, one author noticed that students spent a considerable amount of time attempting to solve the surprise phrase in both conditions. In any case the null hypothesis of less time needed to complete the task (H_{2n}) cannot be rejected. As reported in Table 3, the results of the unpaired t-test are $t = 0.228$, overall standard $h = 3.72$ and $p \leq 0.82$ and 61 degrees of freedom.

In retrospect, the authors speculate that the students using computer assistance to unscramble the word clues may have stayed on the surprise answer phrase task for a longer time period than those in the control condition. This is opposite to the hypothesised direction of less time for the experimental condition and more time for the control condition. The authors believe this was because the students in the experimental condition had confidence in the unscrambled clues found with the assistance of the suggested web sites and therefore were willing to spend more time trying to decipher the surprise answer. Those students in the control group took slightly less time (0.2 minutes or 12 seconds) because the authors believe that they decided more quickly to give up on solving surprise phrases since they were unable to solve as many clue anagrams by hand. In any case, the time difference for the groups to solve the overall task or give up trying was not significantly different.

Finally, Table 4 shows the results of the number of students who correctly solved the overall puzzle (surprise answer) after unscrambling the anagrams. The results show that it cannot be concluded that the experimental group was able to solve a significantly greater number of overall, surprise phrases than the control group. In fact only three subjects in the experimental group were able to solve the surprise answer versus none in the control group. While this may indicate a trend, more testing will be needed with larger sample sizes before any conclusions can be drawn. A t-test was not run since the control group had a variance of zero. The authors conclude that on the basis of these results, a rejection of the null hypothesis to accept the alternative hypothesis that 'When looking at the surprise answers only, the experimental group solved significantly more answers than the control group' cannot be made. Hence, the conclusion that the two groups do not differ significantly in terms of their ability to solve the surprise answer must remain.

Table 4. Percentage of surprise answers solved, experimental vs. control groups.

	Percentage of surprise answers solved				
	Experimental group		Control group		
	M	*n*	*M*	*n*	Mean difference
Scores	.103	29	0	34	.103
Range	0–1	0–0			

5. Discussion

It would appear that the computer is especially useful for solving calculable tasks or rote procedures. The authors are less willing to come to any conclusions when the task involves a creative or inspirational approach. As Plato's Meno paradox would suggest, the use of information technology may enhance creativity just as Plato's discussions with Meno enhanced the thought process. However, while information technology may enhance domain-specific tasks such as unscrambling words, just as Meno had to leap to understand Socrates' argument that virtue like knowledge can be taught, this study's human subjects were expected to leap to a solution of the overall puzzle after unscrambling the clue phrases. Most simply could not make the leap. In short, although the authors were impressed by the fact that more students were able to solve the overall puzzle phrase in the experimental condition than the control condition, due to the small number of successful solutions, they found the results underwhelming nevertheless.

What happened here? The authors noted that the large majority of students in both conditions became bogged down when it came time to creatively piece together the clues for the purpose of solving the overall puzzle phrase. The creative, surprise phrases require a specific and somewhat unique type of brainpower which, after a point, may or may not be aided by the addition of computer power.

Still, the authors can speculate that students with computer assistance will have more time to invest on the creative portion of the activity (the solving of the puzzle phrases). These students would also have more confidence in the unscrambled words attained with computer assistance. These are subjects for future study.

It would appear that the personal computer and related web resources will always serve as an important tool and will be especially useful for assisting in the rote procedures involved in a task. Although this line of research did not prove it, it is widely accepted that efficiencies of information processing and reduction in related task time will be enjoyed when the personal computer is effectively incorporated into a task (Brody *et al*. 2003, Laudon and Laudon 2010). However, if a creative element is involved, then the human dimension must still be considered. Accomplished novelists and master painters probably will not be replaced in the near future by programmed algorithms, robotic tools or what passes for current versions of artificial intelligence purporting to concoct creative output with the flair of a master prestidigitator. Rather, such human activity may be enhanced by the introduction of technological support tools (Masseti 1996, Candy and Edmonds 2000, Shneiderman 2007).

5.1. Reflections

Why is this important? Candy and Edmonds (2000, p. 62) state,

> While everyone has the potential for creativity, not everyone is fortunate enough to have these characteristics in abundance. Of course, there are other factors, such as access to resources and, indeed, the good fortune to be in the right place at the right time. However, we claim that creativity is not accidental, and by understanding how it works, we can learn how to encourage and enhance it. By harnessing this knowledge, there are immense opportunities for the creators of innovative technologies to expand the repertoire of tools and toys that amplify the creative process.

It should be noted that the findings in this study that computers can speed up the process of engaging in rote tasks is perhaps intuitive. Still, these tasks are becoming more pervasive than merely solving anagrams using web resources. Blackberries, Android phones, iPhones, iPads, and mobile devices of every description are being relied upon more and more to download data, accept payments or pay bills, make decisions and engage in long range planning and control. Is it possible that just as casinos speed up the transactions demand for money (Field 1984) but provide little or no substantive increase in wealth (Minnesota Family Council 1996) and may even result in serious social ills (Suwansky 2010), that an over-reliance on these mobile devices, personal computers, and their accompanying applications may have similar deleterious effects? Specifically, will the devices speed up the transactions demand for decisions by decreasing the time for engaging in transactions and/or engaging in critical thinking but truncate the depth of that thinking while ameliorating the creative output and/or compromising the quality of the interpersonal exchange? Who has not watched a YouTube video of people texting or interacting with technology while falling in to a fountain or walking into a wall or crashing a vehicle? All of this is most unfortunate. The point is that the authors think the quality of the creative output may have been compromised by the over-reliance on the unscramble algorithms – but they cannot prove it. The authors speculate that students readily adapted to and accepted the support provided by the software. It enabled them to quickly decipher the words. Why then could not it enable them to solve the puzzle? The solution of the overall puzzle necessitated a creative burst of brainpower that the web resources were not designed to provide. At this point, students were supposed to think on their own. An important question becomes,

> Does the use of computing and web resources foster creative puzzle solving thereby enabling students to 'think on their own' or does the use of these resources merely serve as a crutch that results in an overreliance on technology leading to the stifling of the creative problem solving process?

The determination of the answer to this ancillary question is suggested for future research.

6. Conclusion

Edwards (2000, p. 221), writing on the idea of creativity, states:

> Regardless of how creativity is defined, it is an amorphous concept that is not easily comprehended. As a concept creativity has been studied extensively, across a variety of disciplines and in many situations. However, there exists no consensus as to what the term creative or creativity means, what a creative act entails, or how creativity is recognized. It is apparent that creativity has not been adequately defined and that incongruent findings about the nature of creativity are commonplace in the literature.

As creativity is so difficult to define, conducting research as to how to enhance creativity with technology is also difficult to comprehensively design and control. This paper reports one study that strived to identify possible effects of supporting creative work with technology. Although some support for the positive effect of technology on creative work was found, there clearly remains a need to study this effect further and in different contexts.

In conclusion, Einstein's faux quote is partially correct. Computers are incredibly fast and accurate. People are slow. Whether the combination of computers and people are 'powerful beyond imagination' may in fact depend on the person operating the computer. Is he or she brilliant? Is he creative? Does he or she possess an imagination? If not, speed and accuracy may result, but creative solutions may have to be left to those who have the latent talent, natural ability, and internal skill set needed to solve the task.

Notes

1. http://www.quotationspage.com/quote/29628.html.

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