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The Incubation Effect: Hatching a Solution?

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Numerous anecdotal accounts exist of an incubation period promoting creativity and problem solving. This article examines whether *incubation* is an empirically verifiable phenomenon and the possible role therein of nonconscious processing. An Idea Generation Test was employed to examine (a) whether an incubation effect occurred and (b) the impact of different types of break on this effect. In the Idea Generation Test, two groups of participants were given a distracting break, during which they completed either a similar or an unrelated task, and a third group worked continuously ($N = 90$). The Idea Generation Test was validated against established measures of cognitive ability and personality, and was found to exhibit variance distinct from those marker tests. Most important, results demonstrated that having a break during which one works on a completely different task is more beneficial for idea production than working on a similar task or generating ideas continuously. The advantage afforded by a break cannot be accounted for in terms of relief from functional fixedness or general fatigue, and, although it may be explicable by relief from task-specific fatigue, explanations of an incubation effect in terms of nonconscious processing should be (re)considered.

Since the time of Galton, creativity has often been held to be a crucial component of eminence or genius; however, the issue of how creativity is to be defined has proven contentious. It is an open question whether there is a generalizable creative ability or whether the different instantiations of creativity involve distinct and incommensurable abilities (Hocevar, 1981). Among those who believe that creativity is unitary, there is disagreement over whether it can be captured by the construct of novelty, or whether the appropriateness of the product should also be taken into consideration when determining creativity (e.g., Sternberg & Lubart, 1995). In practice, creativity is often conceived of as a form of problem solving, with *problems* being broadly defined as goals to be reached (Lubart, 2001). Although this approach is based on a limited view of creative endeavour, it is more amenable to empirical investigation (than views that include the esoteric and intangible). The present study focuses on that conceptualisation by examining an aspect of creativity that would seem to have considerable utility in everyday life, namely the generation of novel ideas.

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There is a considerable overlap between the literature on creativity and that on problem-solving. Historically, problem-solving was a focus of theorising by Gestalt psychologists and the idea that sudden awareness of a correct solution to an unresolved problem demands a psychological explanation appears in the early Gestalt literature (Koffka, 1935/1962). However, it is arguable that Wallas' (1926) model was the most influential from this early period of investigation. Wallas' model involved four stages:

1. preparation, which involves defining a problem and consciously attempting to solve it;
2. incubation, wherein, when a solution has not been forthcoming, conscious work ceases, but continues nonconsciously;
3. illumination, which encompasses the moment of insight; and
4. verification, whereby the solution is refined and confirmed.

Although the preparation and verification stages have been the subject of considerable research within both cognitive and differential psychology, the incubation phase is somewhat more mysterious, and has proven less amenable to scientific investigation.

Anecdotal accounts of creative ideas or solutions "springing to mind" after a period of incubation abound, but research on that topic has been comparatively limited. Despite the paucity of empirical investigations, the majority of studies performed in this field have yielded results that suggest that incubation is a genuine phenomenon that demands explanation. Of the approximately 50 studies that focus on incubation effects, more than 75% have shown evidence of incubation in at least one of the experimental groups. However, beyond showing that incubation exists, studies have been methodologically heterogenous. This has led to much contention in the literature especially regarding causes of the incubation effect.

Different studies examine many different facets of the incubation effect such as: activity before incubation, the type of problem employed, clues during incubation, length of the incubation effect, and different activities employed in the incubation period (Dodds, Ward, & Smith, 2004). Two of these domains were fundamental to the present study—the type of problem used and the activity given in the incubation period. These variables were manipulated in an attempt to test the relative virtues of nonconscious idea generation versus other competing theories, as explanations of the incubation effect.

PROBLEMS WITH CONVERGENT THINKING TASKS

Although the majority of studies have supported the existence of an incubation effect, most of those used a convergent problem-solving task (e.g., Dreistadt, 1969; Murray & Denny, 1969), whereby individuals have been aware that they have not found a solution, and thus, may have still been *consciously* seeking a resolution. Even in studies that allow multiple solutions to a single problem, such as Penney, Godsell, Scott, and Balsom (2004), where the participants were asked to come up with as many five-letter words as they could from a 10-letter starter word, it is a logical assumption that the number of acceptable words is finite. It is also likely that the participants were aware during the incubation period that they had not solved, or exhausted, all possibilities to reach a resolution of, the problem. This is important because participants may have been consciously, albeit intermittently, working on the problem while purportedly engaged in other tasks.

It can also be argued that of the minority of convergent thinking tasks that have not found an incubation effect (e.g., Dominowski, 1972; Dominowski & Jenrick, 1972; Olton, 1979; Olton & Johnson, 1976) that incubation processes may have still been occurring. Implicit in these studies has been the view that incubation can only be evidenced by the achievement of a correct solution. Nevertheless, it may be argued that any ideas produced after conscious work on a problem has ceased could be considered as indicative of the presence of an incubation effect.

The present study used a divergent thinking task, increasing the likelihood that participants were not consciously working on the problem in the incubation period for two reasons:

1. There was no problem left unsolved at the end of the first testing segment. Presumably this leaves the participant with a sense of resolution, rather than an insistent feeling that an outstanding problem needs to be solved.
2. As the task appeared to be completed after the first testing segment, participants had no reason to think that they would return to it. (Presumably these two factors, combined, eliminate any sense of intrinsic reward that might otherwise be gained from solving an outstanding problem and thus remove the motivation to consciously work on the problem).

Both of these propositions are assumptions based on the subjective experience of the participants, and the authors highlight that they are not irrefutable facts. However, to try to verify these assumptions by asking the participants of their subjective state would be counterproductive to the design of the experiment, not least because it would require the participant to consciously think of the task.

Fulgosi and Guilford (1968) pioneered the use of a divergent thinking task in a test of the incubation effect. They showed that participants came up with more consequences to a situation after a break involving other cognitive activity than when they were required to continuously work on the same problem. Their results were equivocal, however, because they only showed a significant effect after a 20-minute incubation period and no effect after a 10-minute incubation effect. Their results were also incapable of discriminating between participants who knew they would get a second chance at the task and those who had no indication of this fact. Snyder, Mitchell, Ellwood, Yates, and Pallier (2004a) revisited the use of a divergent thinking task in a simple design employing an incubation period to assess whether nonconscious idea generation is a possible explanation of the incubation effect. Participants were required to generate as many possible uses for a piece of paper as they could. When participants had seemingly exhausted their supply of ideas, they were told that the task was over, and were interviewed in order to collect biographical information. Afterwards, to their surprise, participants were asked once again to provide uses for paper. Results demonstrated that participants produced a burst of new ideas after the break.

The possibility that the incubation effect might be the result of nonconscious idea generation informed the present study. As outlined above, the authors designed the study to maximize the possibility that the participants were not consciously working on the experimental task during the incubation period. The design also manipulated the tasks employed in the incubation period in an attempt to discriminate between different putative causes of the incubation effect. In addition, the discriminant validity of the task, a measure of so-called *Ideational Fluency* (IF; see Carroll, 1993), was examined in relation to established measures of personality and tests of intelligence derived from the framework of the theory of fluid and crystallized abilities (see, e.g., Horn & Noll, 1994) to see if it was distinct from these constructs.

Problems With Nonconscious Processing as a Causal Explanation

In cases such as those cited above, where an incubation effect has purportedly been demonstrated, accounts in terms of nonconscious processing have proven contentious (Dorfman, Shames, & Kihlstrom, 1996), partly because they rely on unobservables (see, e.g., Feldhusen, 1995). Post-behaviorism, many psychologists have attempted to explain away the incubation effect, claiming that the value of a break lies in enabling recovery from fatigue, or relief from functional fixedness (Posner, 1973). Explanations formulated in terms of recovery from fatigue state that a break relieves neural fatigue within an individual, providing them with renewed energy to attempt a solution. Proponents of functional fixedness claim that a rest allows individuals to break their mindset, to restructure the problem and approach it differently, either by ‘‘reducing the ‘recency’ value of inappropriate strategies,’’ or by selectively forgetting less useful memories in favor of more relevant ones (Ochse, 1990, p. 198).

We contend that there is at least as much evidence for nonconscious idea generation as there is for neural fatigue as an explanation of the incubation effect, and that the lack of evidence to differentiate these two competing theories is equally problematic for both. Empirical validation for the neural fatigue theory relies upon something not being evidenced, that is, the putative neural firing in the incubation period that would otherwise fatigue the neuron. Although there are direct behavioral measures of specific neurons decreasing their firing rate in unrelated areas such as pattern discrimination, there is none for so complicated an area as complex cognition.

Contrastingly, there is abundant evidence of the manifestation of nonconscious processing, because humans continuously perform behaviors that are not consciously directed. Similarly, neural firing is recorded throughout the brain continuously, yet the majority of this activity does not result in conscious thought.

There are, of course, attendant problems for proposing nonconscious processing as the cause of the incubation effect. There is a conundrum in the behavioral manifestation of a cause that is, by definition, not discoverable by the individual and not presently objectively observable by neural imaging.

Theoretical Support for Nonconscious Processing

In addition to the empirical evidence, there are theoretical grounds for asserting nonconscious processing as a possible explanation of the incubation effect. Dorfman et al. (1996) proposed that implicit memory provides a means by which to reconceptualize nonconscious processes, making possible the readmission of the study of incubation to a scientific psychology. Holyoak (1995) pointed out that the existence of neural networks provides a means of grounding theories of nonconscious aspects of problem solving. Elaborating on that proposition, Gabora (2002) provided a neural network-inspired model of creativity. She based her account on the premises that memory is sparse and distributed, in that each item is stored across many locations, and each location helps to store many items. Additionally, memory is content-addressable, insofar as each memory is characterized by a specific pattern of excitation and inhibition across neurons. Associated memories share activation in common. Individuals differ in the richness of their associations, or the extent to which their memories overlap. According to Gabora, those with greater associative richness have access to a larger, more varied number of responses in creativity tasks.

The current study investigates the incubation effect from the perspectives of both individual differences and experimental cognitive psychology. This makes possible the examination of whether idea generation is a cognitive ability upon which people differ, which may contribute to successful life-outcomes, and affords a greater appreciation of what incubation might involve. Differential psychologists, generally, have been less averse to studying creativity than have modern cognitive psychologists. According to Ochse (1990), Guilford articulated the most influential factor-analytical account of creativity and problem solving, basing his theory on the existence of distinct cognitive abilities, of which creativity is one. Carroll (1993) examined *fluency* and *creativity* factors, particularly those associated with what Guilford (1967) referred to as ‘‘divergent production.’’ In his reanalysis of some 477 data sets, Carroll identified an Ideational Fluency factor, which included ‘‘tasks in which the participant was required to produce, within a fairly liberal time limit, a series of different words or phrases concerned with a specified topic or concept’’

(p. 396), which is identical to French, Ekstrom, and Price's (1963) construct of the same name.

Unlike traditional tests of Ideational Fluency, the test used in this study included a distracting break halfway through. That made it possible to establish whether a break increases response output when, to the participant's surprise, the task is resumed. To the extent that a break enhances performance, it may be that nonconscious processing or incubation is occurring.

Furthermore, we hypothesized that greater output would result from a break comprised of a completely unrelated task over one comprised of a task that taxed the same resources that would otherwise have been available to idea generating nonconscious processes.

METHOD

Participants

Ninety first-year psychology students, with an average age of 22.0 years, participated as a course requirement. Sixty-five participants were women. Forty-nine participants were born in Australia and 59 nominated English as their first language. Participants were recruited for three conditions: (a) a continuous testing condition; (b) a break condition using a task related to the IF test; and (c) a break condition using a distracting task unrelated to the IF test. There were 30 participants in each condition. The experiment was conducted with the approval of the University's Human Ethics Committee.

Task Descriptions

Apart from the Idea Generation Test, there were standardised psychometric tests of fluid intelligence (Gf), crystallised intelligence (Gc), long-term memory (TSR). and working memory (SAR), as well as the OCEANIC personality inventory, a measure of the Big-Five Factor Model.

Idea generation test. This task was based on Cattell's Things Categories Test (French, Ekstrom & Price, 1963), and required participants to list as many possible different uses for a piece of paper, an item that is familiar to all. There were three conditions:

1. *Continuous*, wherein participants were required to work on the task, without a break, for 4 minutes.
2. *Controlled Associations* had two 2-minute sessions separated by a break. Participants were interrupted after 2 minutes, told that the task was over, and required to perform the Controlled Associations Test (details given in the following). That test took approximately 5 minutes to complete, after which, to participants' surprise, they were requested to generate new ideas for uses for a piece of paper for a further 2 minutes.
3. *Myers-Briggs Type Indicator (MBTI)* also had two sessions with a break. Participants were interrupted after 2 minutes (as in the controlled associations condition), told the test was over, and asked to complete the MBTI (for 5 minutes) during the break, after which participants were requested to generate new ideas for uses for a piece of paper for a further 2 minutes.

Matrices (Gf). In this test (Stankov & Roberts, 2001), participants were presented with a series of 3×3 matrices, with all but the bottom right-hand block containing patterns made up of *o*s, +s, and blanks. Participants were required to identify the logical series, and to fill in the empty square with the appropriate combination of *o*s, + s, and blanks to complete the matrix pattern. The task involved three practice and eleven test items.

Letter swaps (Gf). This test (Stankov & Crawford, 1993) presented participants with three letters (*J*, *K*, and *L*) in various orders, and required them to carry out mentally a number of letter swaps (e.g., 'Swap the 1st and 3rd letters') and identify the resulting order of letters. There were two practice and 10 test items, employing 2, 3, 4, or 5 swap operations.

Vocabulary (Gc). In this test (Stankov, 1997), participants were asked to select the most appropriate definition (from four alternatives) for a series of words. The test comprised two practice and 10 test items.

Esoteric analogies (Gc). In this test (French et al., 1963), a number of pairs of related words were presented, with participants being required to identify the relationship between each pair of words and apply it to select the most appropriate response to a prompt word (from four alternatives), e.g., Light is to Dark as Happy is to: Eager, Gay, *Sad*, Glad. There were two practice and 10 test items.

Word associations (TSR). This test (French et al., 1963) presented participants with a series of pairs of words, and gave them 4 minutes to generate a word that provides an association between each pair of words (e.g., *Number* and *Nobility*, for which an appropriate answer would be *Count*, as people count numbers and a count is a member of the nobility). The test contained two examples and 10 items.

Controlled associations (purportedly a TSR measure). In this test (French et al., 1963), participants were provided with a number of target words, and given 1 minute per word to produce as many synonyms as possible. The test contained one example and four test items.

Although Test 6 is currently widely accepted as the defining task for TSR, it remains unclear from Carroll's (1993) reanalysis of the position of Test 7, although both would appear to share a relationship in Carroll's Domain of Idea Production. Interestingly, IF is also considered part of that Domain and it was hypothesized, from previous studies reported in the literature (e.g., Knoell & Harris, 1952), that Tests 1 and 7 might define a separate factor from the TSR task.

Paired associates (SAR). In this test (French et al., 1963), participants were given 3 minutes to memorize 15 pairs of first names. They were then presented with the latter name of each pair, and were given 2 minutes to recall the initial name with which each was associated.

OCEANIC. This personality inventory (Roberts, 2000) required participants to express their level of agreement (on a five-point Likert scale) with 60 behavioural statements seeking to measure the Big-5 factors of Openness to Experience, Conscientiousness, Extraversion, Agreeableness, and Neuroticism.

Procedure

Testing was conducted in small groups. Participants were welcomed, given an overview of the testing session and informed of their rights under the ethics guidelines. Informed consent was obtained. They were asked to complete forms requesting basic demographic information. In the *continuous* and MBTI conditions, participants then completed the word associations, controlled associations, and paired associates tasks, which were paper and pencil tests timed by the experimenter. Those in the controlled associations condition completed only the word associations and paired associates tests, as the controlled associations test was reserved for the distracting break in the Idea Generation Test.

Following the paper and pencil tests, participants completed the computerized OCEANIC inventory and cognitive abilities tests, which were self-paced. While they were doing the computerized tests, a second experimenter (at convenient intervals) took each participant individually to an adjacent room to administer the Idea Generation Test. An audio recording of responses for the Idea Generation Test was made so that the experimenter could check that answers were not replicated, and the speed of responding was recorded accurately on a computer. When participants had finished the session, which took approximately an hour-and-a-half, the experimenter debriefed them and thanked them for their participation.

RESULTS

Descriptive Statistics

The means and standard deviations for each test are presented in Table 1. As can be seen, none of the tests revealed floor or ceiling effects. Additionally, the means and standard deviations are consistent with those of previous studies in our laboratory using the standardized tests (e.g., Danthiir, Roberts, Pallier, & Stankov, 2001). Similarly, the scores obtained on the OCEANIC were typical of those previously obtained at the University of Sydney from undergraduate samples.

Correlations Between Variables

In order to establish whether idea generation is a robust cognitive ability, the pre- and post-break scores were correlated. The correlation was 0.65 ($p < 0.05$), indicating reasonable test-retest reliability and therefore supporting the existence of a reliable cognitive ability. Moreover, individuals differed considerably on this ability, with scores ranging from 8 to 47. Because the correlation between the two testing sessions was reasonably substantial, responses were summed and the total score for idea generation was used in the analyses that follow. Inspection of Tables 2 and 3 reveals that, generally speaking, idea generation proved to be independent of other cognitive abilities and personality traits, with the exception of controlled associations and matrices, with which it correlated 0.28 and 0.21, respectively ($p < 0.05$ in both cases).

As expected, inspection of Table 2 reveals correlations between the cognitive abilities tests that are, in general, supportive of Gf/Gc theory.

Inspection of Table 3 reveals no significant relationship between any of the Big-Five dimensions, except

TABLE 1
Descriptive Statistics for the Idea Generation and Cognitive Abilities Tests

Test	*Mean Accuracy Score*	*Standard Deviation*
Idea generation	22.5	8.4
Matrices	55.4%	22.1
Letter swaps	77.8%	20.7
Vocabulary	66.0%	18.1
Esoteric analogies	66.8%	17.1
Word associations	28.4%	21.4
Controlled associations	39.7%	15.5
Paired associates	43.4%	22.3

TABLE 2
Correlations Between the Idea Generation Test and the Cognitive Abilities Tests

Test	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1. Idea generation	1							
2. Matrices	.21	1						
3. Letter swaps	−.05	.44	1					
4. Vocabulary	.04	.39	.30	1				
5. Esoteric analogies	.13	.43	.23	.43	1			
6. Word associations	.19	.14	.06	.30	.28	1		
7. Controlled associations	.28	−.04	−.21	−.02	−.05	.05	1	
8. Paired associates	.08	.21	.20	.35	.27	.40	.24	1

Extraversion, where a low ($r = 0.22$) correlation appeared. This may be due to the face-to-face nature of the testing procedure.

Exploratory Factor Analysis

In order to further examine the correlations presented in Table 2, a Principal Components Analysis (with Oblimin rotation) was conducted on the idea generation and cognitive abilities tests. It produced a three-factor solution, presented as Table 4.

These factors were interpreted as follows:

1. Cognitive Ability, defined by established measures of Gf/Gc, especially tests containing a reasoning (Gf) component (matrices, letter swaps, esoteric analogies, vocabulary, and controlled associations);
2. IF, comprising divergent production tasks (idea generation and controlled associations); and
3. Verbal memory, defined by linguistic tasks reliant on memory (word associations, paired associates, vocabulary, and esoteric analogies).

Of interest, and as has been reported elsewhere, vocabulary and esoteric analogies proved to be factorially complex in this study (see, e.g., Danthiir et al., 2001; Pallier, Roberts, & Stankov, 2000), as did controlled associations.

TABLE 3
Correlations Between the Idea Generation Test and Personality Dimensions

Test	*1*	*2*	*3*	*4*	*5*	*6*
1. Idea generation	1					
2. Openness	.10	1				
3. Conscientiousness	−.04	.34	1			
4. Extraversion	.22	.02	.08	1		
5. Agreeableness	−.00	.38	.28	.41	1	
6. Neuroticism	−.01	.11	.01	−.39	−.10	1

TABLE 4
Pattern Matrix for Principal Components Analysis (With Oblimin Rotation) of the Idea Generation and Cognitive Abilities Tests

Test	*Factor 1*	*Factor 2*	*Factor 3*
Idea generation		.87	
Matrices	.85		
Letter swaps	.73		
Vocabulary	.46		−.50
Esoteric analogies	.57		−.31
Word associations			−.77
Controlled associations	−.32	.66	
Paired associates			−.80

Note. For clarity, only salient loadings (>0.3) are reported.

The Effect of a Break on Idea Generation

As is evident from Table 5, group scores did not differ significantly in prebreak performance.

Participants produced, on average, 57% as many new ideas in the post-break phase as they had in the initial session, although there were differences in the post-break response pattern, depending on condition (see Table 5). These apparent differences were tested via an analysis of variance (ANOVA).

As can be seen in Table 5, the presence and type of a break had a substantial effect on the number of ideas produced in the second half of the task, $F(2, 87) = 3.4$, $p < .05$). Post-hoc Tukey's HSD tests showed that individuals who undertook the MBTI during a break produced significantly more uses for paper afterwards than did participants who worked continuously (significant at the .05 level). The other comparisons were not significant.

To supplement these findings, effect sizes were calculated using Cohen's d. A break during which the MBTI was completed conferred a modest advantage on idea generation as compared to continuous idea production ($d = 0.67$; "medium" effect size according to Cohen, 1992). Furthermore, the type of break had a small effect, with MBTI improving performance relative to Controlled Associations ($d = 0.44$). There was no noteworthy benefit of a break involving Controlled Associations relative to continuous work ($d = 0.16$).

TABLE 5
Mean Number of Responses in Each Condition for the Idea Generation Test

Time Interval	*Continuous*	*Controlled Associations*	*Meyers-Briggs Type Indicator*
Prebreak	14.3	14.6	14.4
Postbreak	6.9	7.6	9.8

Note. For the Continuous condition, pre-break is the score for the first two minutes and post-break the score for the second two minutes of work.

DISCUSSION

The Distinctiveness of the Idea Generation Test as a Creativity Marker

The Idea Generation Test captures an attribute upon which individuals differ considerably, as demonstrated by the wide variation in the number of responses produced. The moderately strong correlation between the two testing sessions for idea generation suggests that this is a relatively stable cognitive ability, and that the test has reasonable test–retest reliability. Some individuals excel at idea production, and they continue to do so throughout the course of the task; others are consistently less fluent.

The distinctness of idea generation, a measure of Ideational Fluency, from the Cognitive Ability factor is interesting and somewhat unexpected, as many theorists (e.g., Feldhusen, 1995; Sternberg, 2001) have argued that intelligence is necessary for "the development of a large, fluent knowledge base," which is manipulated in various ways to solve problems or produce creative ideas (Feldhusen, 1995, p. 255). Also unexpected is the absence of any meaningful relationship between idea generation and personality. Previous research has suggested a more substantial link between creativity and extraversion (Martindale & Dailey, 1996), as well as between creativity and openness to experience (Martindale, 1989; Rawlings, Twomey, Burns, & Morris, 1998). Obviously, this was not the case in the present study.

Support for Incubation: The Optimum Break

Individuals were generally less productive in the post-break phase than in the initial session, presumably because they tended to exhaust their most obvious responses in the early stages of the test. However, this performance decrement was moderated by the existence and type of break provided. A break in which individuals are occupied on a completely different task (MBTI) is clearly beneficial compared to working continuously on the same or a similar task (continuous performance and controlled associations, respectively). The effect size analyses shed further light on this pattern of results. Not only is switching to an unrelated task better than working continuously, but it is also superior to a break task involving similar cognitive demands.

Performance was enhanced by a break, despite the fact that participants thought the Idea Generation Test was over, and were engaged on a cognitively demanding distractor task during the break, precluding conscious effort. Thus, these results provide support for an incubation effect. Apart from demonstrating the possible existence of an incubation effect, these findings have implications for the way in which incubation has previously been explained. It is apparent that the benefits of a break are not reducible to relief from functional fixedness. Such accounts postulate that all types of break from the subject matter of a task should be equally beneficial, as interruptions remove the mindset perpetuated by specific problem content. On the contrary, the results of the present study suggest that taking a break from work on a topic is differentially advantageous, and depends on the type of task undertaken during the break.

These data indicate that it is not merely by providing relief from general fatigue that a break is effective. Both conditions involving a break required individuals to work on cognitively demanding (and, thus, fatiguing) distractor tasks. Yet, performance in the MBTI condition was enhanced, relative to output for those who worked continuously on the Idea Generation Test. Accounts in terms of general fatigue predict that all conditions deployed in the present study would produce similarly diminished output throughout the course of the task.

Is Idea Generation Occurring Nonconsciously During the Break?

It is an open question whether the present outcome constitutes a demonstration of nonconscious idea generation occurring during the break, or whether it exemplifies relief from task-specific fatigue (in contrast to general fatigue, discussed above). Both of those accounts postulate that a break from tasks deploying the same set of neurophysiological resources should facilitate performance. This prediction appears to be supported by the results.

The Controlled Associations Test resembles the Idea Generation Test, insofar as both require individuals to produce a number of alternative responses related to a particular topic. They are purported measures of Associational Fluency and Ideational Fluency, respectively, as characterized by Carroll (1993). In the current study, those constructs appear to be distinct from TSR, as assessed by the Word Association Test. This procedural similarity was confirmed by the results of the factor analysis. Although the controlled associations and idea generation tasks differ in content, and are by no means identical in their processing requirements, it is reasonable to assume that the similarity that exists causes recruitment of overlapping neural circuits (cf. Gabora, 2002). Because of this, the Controlled Associations Test can be considered to provide only a partial break from idea generation, whereas the MBTI constitutes a complete break.

The prediction of the task-specific fatigue and nonconscious processing approaches is the same—after a break, people generate a greater number of ideas than those who work continuously (see Table 5). However, the means by which these predictions are derived are distinct. Accounts in terms of nonconscious processing state that problem-solving can continue during a break, to the extent that neurophysiological resources are available. On the other hand, proponents of the task-specific fatigue approach claim that no such processing occurs during the break, but that a break involving a distinct task allows neural circuits to recover from fatigue, whereas a similar task allows a lesser degree of recovery. Unfortunately, it is difficult to envisage how to test these theories differentially using a behavioral approach. Arguably, this is a matter for neurophysiological investigation, and the research team intends to conduct fMRI studies to this end.

In common with many studies in this area, the research presented here related creativity to idea generation ability. A current limitation of quantifying this approach is that it fails to consider the more qualitative aspects of creative output, which are entailed by the facets of flexibility and originality. The authors are presently validating a measure designed to (quantitatively) reflect novelty of responses, termed the Creativity Quotient (CQ; Snyder, Mitchell, Bossomaier, & Pallier, 2004b), which marries flexibility and originality in an encompassing metric. CQ is related to French et al.'s (1963) construct of *semantic spontaneous flexibility*, which is "the ability to produce a *diversity* of verbally expressed ideas in a situation that is relatively unrestricted" (p. 50, italics added), or, in their later scheme, *flexibility of use*, which is "the mental set necessary to think of different uses for objects" (Ekstrom, French, & Harman, 1976, p. 197). At the same time, CQ incorporates a distinction noted by Carroll (1993), by addressing both quantitative and qualitative features of idea production.

Beyond their role in predicting genius or eminence, tasks such as idea generation have clear potential benefits for educational and industrial and organizational psychology, particularly as the value of creativity and innovation to education and corporate success is increasingly being recognized (Bereiter, 2002; Florida, 2002). Future research is directed at ascertaining the predictive validity of *the creativity portrait*—a battery of idea generation tasks broad enough to approximate Guilford's (1967) original parameters—in a corporate context.

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