Person. individ. Diff. Vol. 7, No. 2, pp. 169–174, 1986
Printed in Great Britain.

0191-8869/86 $3.00 + 0.00

THE ROLE OF ABILITY IN CREATIVE 'INCUBATION'

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(*Received 3 June 1985*)

Summary—While many people report interruptions from problem-solving to be beneficial for the creative process ('incubation'), experimental demonstration of the phenomenon has been difficult. Factors that might lead to incubation effects are discussed and implemented in a study in which 80 university students solved word-association problems under continuous work or interrupted conditions. The interruptions involved work on other problems, other problems plus periods of conversation or other problems plus work on an unrelated mental rotation task. The results showed the incubation phenomenon in one condition and, most importantly, the ability level of the *S*s for the task involved determined whether incubation would occur. High-ability *S*s benefited from the interruption involving the rotations task, while low-ability *S*s did not show any incubation effects. Comparisons to previous studies and suggestions for future research are made throughout.

INTRODUCTION

Interruptions have been described as an important part of the creative process. Most people can relate experiences in which, after unsuccessfully working at a problem, the answer suddenly comes to them either when they are not working at the problem or when they return to it after an interruption. A similar experience occurs when attempting a difficult memory retrieval: the desired memory may suddenly appear after overt attempts have stopped (cf. Read and Bruce, 1982). These phenomena have been labelled 'incubation' (Wallas, 1926) and this term will be used here although it should be noted that the unconscious processing explanation that is implied in the incubation analogy is only one of many possible explanations (Silveira, 1972; Woodworth and Schlosberg, 1954). Many anecdotal reports suggest that incubation is an important part of creative production (e.g. Ghiselin, 1952; Woodworth and Schlosberg, 1954), but experimental support for the phenomena has been difficult to gather.

Experimental studies of incubation have used a variety of problems and paradigms and yet the phenomenon remains elusive (Olton, 1979). Olton and Johnson (1976) hesitantly suggest that

> "incubation may be something of an illusion, perhaps rendered impressive by selective recall of the few but vivid occasions on which great progress was made following separation from a problem and forgetting of the many occasions when it did not." (p. 629)

While this must always be kept as a possibility, the inadequacies of the previous research suggest that this conclusion may be premature. These inadequacies include giving interruptions *at the expense* of work on the problems (Gall and Mendelsohn, 1967; Mendelsohn and Gall, 1970; Dreistadt, 1969). The phenomenon is not that interruptions are *better* than work at a problem, but that interruptions may be beneficial if that work has been fruitless. In addition, many studies have used dependent variables that may be insensitive to incubation effects. For example, Murray and Denny (1969) used a single insight problem and simply counted the number of *S*s who solved the problem under continuous work and interrupted conditions.

The primary goal of this study, then, was to test for incubation effects under conditions thought to be more conducive to their appearance. To do this an attempt was made to ensure the *S*s were 'stuck' on the problems before any interruptions were introduced since incubation may only occur once the *S*s have reached an impasse (Silveira, 1972). Also, a dependent variable consisting of the number of problems solved out of five was used to provide a sensitive measure.

Another important condition might be the duplication of the real-life conditions where incubation is said to occur. Much of the anecdotal evidence comes from people who have struggled with a

problem for a long time (often years). It is likely that many interruptions were involved here as day-to-day activities continued. However, the experimental paradigms that have been used involve only a single interruption separating two periods of work on a problem (compared to an equivalent amount of work with no interruption). If one interruption can be beneficial, several interruptions may be even more beneficial. In the present study three interruptions separated four periods of work on the problems.

Many previous studies have also been limited in the types of interruptions that have been used (but see Olton and Johnson, 1976; Beck, 1979). Perhaps incubation will only occur when one is doing relatively simple tasks that allow work on the problem at some low level of consciousness (the 'incubation' analogy). On the other hand, interruptions may be beneficial because they get the person 'away' from the problem and allow a fresh outlook (set-breaking). Olton and Johnson (1976) and Beck (1979) both found no difference in incubation with the type of interruption used, but this still might be an important factor. In the present study three types of interruptions were tested. In one condition the *S*s interrupted work on a problem to work on other similar problems. In another condition *S*s were interrupted to work on other problems and engage in conversation with the experimenter for 5 min. In a third condition *S*s worked on other problems and a mental rotations task that was unrelated to the word problems. These interrupting activities were chosen because they induce the *S*s to get progressively 'further' from the problems they are unable to solve. Thus, one group simply works on other problems of the same type. Another group works on other problems and engages in conversations that are unrelated to the problems at hand, but still verbal in nature. A third group attempts other problems and works on a spatial rotations task that is unrelated to the association problems and non-verbal (spatial) in nature. If 'getting away' from the problem is an important factor for incubation then these conditions should provide progressively more facilitation.

Another important factor might be individual differences in abilities for the problems involved. Murray and Denny (1969) found that an interruption did facilitate problem-solving for low-ability *S*s, but it inhibited problem-solving for high-ability *S*s. They suggested that low-ability *S*s "may be characterized by initial blocking or fixation on stereotyped responses" and the interruption may have "weakened these dominant responses, perhaps by a mechanism similar to retroactive inhibition, thereby permitting the occurrence of the more remote associates necessary for solution" (pp. 274–275). On the other hand, the interruption may only disrupt the "orderly search process" (p. 275) of the high-ability *S*s.

Ability level was measured by Murray and Denny (1969) with the Gestalt Transformation Test (GTT) and the problem was an insight problem that required transferring steel balls from one container to another from a distance of 8 ft using a number of common objects (e.g. string, pliers). It is questionable whether the GTT is an appropriate measure of ability on such a problem. This is reflected in the failure of low- and high-ability *S*s to solve a different number of problems. Also, the results reported by Murray and Denny (1969) could not be replicated by Dominowski and Jenrick (1972). Further, the Murray and Denny results are counter-intuitive. Anecdotal reports of incubation are often associated with highly creative people so one would expect people of high ability to benefit from interruptions.

To investigate further the role of ability level in incubation the present study used a direct measure of problem-solving ability. The Remote Associates Test (RAT; Mednick, 1962) was used both as a source of problems and as a measure of problem-solving ability. The 30 problems from the test were given initially and the number solved provided the measure of ability. The remaining unsolved problems were then used to test for incubation effects. Thus, the measure of ability comes *from the same set of problems used to test for incubation.* Division of the Ability scores into high and low categories ensures that the *S*s actually do differ in ability at this task.

The RAT was originally designed as a test of creativity. Mednick (1962) proposed that creativity involves using remote associates and those people who have relatively flat associative hierarchies will be the most creative. He designed the RAT to measure the ability to generate and use remote information in problem-solving. The RAT has been shown to have a moderate amount of discriminative and predictive ability (see Wallach, 1970), but it can be criticized for being too highly correlated with measures of verbal intelligence (e.g. Katz, 1983). In the present study the RAT was only used as a source of problems to be solved.

In summary, *S*s were introduced to the RAT and five unsolved problems were selected for the

incubation task. The *S*s were then tested under one of four conditions: Continuous Work (a control group working with no interruptions), interruptions of work on other similar problems (Other Problems), interruptions of other problems plus conversation periods (Problems + Conversation) or interruptions of other problems plus work on a mental rotation task (Problems + Task). The number of problems solved out of the selected five served as the dependent variable and the baseline RAT scores served as a measure of ability.

METHOD

Subjects

Eighty native-English first-year psychology students (40 males and 40 females) from McMaster University served as *S*s to fulfill a course requirement. Each *S* was tested individually in a session lasting approx. 2 hr. All *S*s were randomly assigned to their conditions by a predetermined pattern.

Materials

Thirty problems were taken from the College, Adult, Form 1 of Mednick's (1962) Remote Associates Test (RAT). The object of the problems was to find one word that is associated with the three words given. For example, the solution to *birthday*, *surprise* and *line* is *party*.

Procedure

All the RAT problems were typed on cards to facilitate individual presentation. The instructions to the RAT were read to the *S*s and four example problems were given and explained before the experiment began.

Phase 1. All *S*s received the same treatment in this phase. Each problem of the RAT was presented and the *S*s were encouraged to guess as much as possible. Up to 2 min were allowed for work on each problem and solution times were recorded throughout.

Of the problems not solved in the initial 2-min periods, five problems were selected at random for further study. These five problems were then presented again for 1 min each. If any of the problems were solved during this period an additional problem was randomly selected. This procedure resulted in five problems that had not been solved after a total of 3 min of work. This ensured that the *S*s were 'stuck' on these problems before the second phase of the experiment began. The Ability score for each *S* was the number of problems solved after Phase 1 was complete.

Phase 2. In Phase 2 the *S*s were paid $1.00 for each problem they could solve of the selected five in an attempt to increase the motivation of the *S*s. It was in Phase 2 that the treatment of the *S*s differed, and four problem-solving conditions were tested (20 *S*s each). In the *Continuous Work* condition each of the problems was presented for 8 min, or until they were solved. Thus, each problem was worked on for an 8-min continuous work period. In the *Other Problems* condition each problem was presented for 2 min each. The problems that remained after this time were then randomized and presented again for 2 min each. This was repeated until each problem was attempted for four 2-min periods. Thus, work on any particular problem was interrupted by work on other problems. The number of problems involved in each interruption could range from 0 to 4 and was determined randomly.

In the *Problems + Conversation* condition each problem was first attempted for 2 min, and then the *S*s were engaged in conversation by the experimenter for 5 min (this usually involved a discussion of the introductory psychology class all the *S*s were attending). Any remaining problems were then randomized and presented again for 2 min each. This was repeated until there were four 2-min work periods and three conversation periods. Thus, the interruptions from work at a particular problem involved working on 0–4 other problems plus 5 min of conversation with the experimenter.

In the *Problems + Task* condition the periods of conversation were replaced by 5-min periods of work at a mental rotations task. This task involved rotating a two-dimensional figure such that the labelled ends matched two labels provided by the experimenter. This task was quite difficult and was chosen to be unrelated to the word-association problems used to test for incubation effects. Thus, in this condition work at a particular problem was interrupted three times by work at other problems and the rotations task.

Equal numbers of males and females were tested in each condition and the author acted as experimenter for half the *S*s while a paid female assistant acted as experimenter for the remaining half. Preliminary analyses indicated that these factors of gender and experimenter did not emerge as main effects or interactions so they were dropped from the main analysis.

RESULTS

The effects of incubation are seen during or after an interruption activity so, to get a pure measure of incubation effects, the dependent variable used in the analyses was the number of problems solved (expressed as a percentage) of those remaining after the first interruption for the interrupted *S*s, and the corresponding last 6 min of work for the Continuous Work *S*s. The Ability scores were divided into high and low categories by a median split within each condition (the sample sizes for the low- and high-ability groups in each condition are: Continuous Work 10/10, Other Problems 9/11, Problems + Conversation 11/9, Problems + Task 10/10). A two-way ANOVA was performed with condition (4) and ability level (2) as the factors (both between-*S*s). The only significant main effect was one of condition [$F(3, 48) = 3.533$, $P < 0.05$; all MSe = 631.62]. The mean percentage of problems solved were: Continuous Work (12.15), Other Problems (29.20), Problems + Conversation (19.55) and Problems + Task (34.40). A Newman–Keuls analysis (with $\alpha = 0.05$) revealed a significant difference between the Continuous Work and Problems + Task conditions.

There was also a significant interaction of condition and ability level [$F(3, 48) = 4.20$, $P < 0.05$]. The nature of this interaction can be seen in Fig. 1. While the high-ability *S*s solved the most problems under the Problems + Task condition, the low-ability *S*s solved the most problems under the Other Problems condition. Tests of simple main effects showed that the effect of condition was significant for both the high- and low-ability *S*s [$F(3, 48) = 4.28$, $P < 0.05$ and $F(3, 48) = 2.90$, $P < 0.05$, respectively].

A Newman–Keuls analysis of the condition means for each level of ability revealed that the only significant difference for the high-ability *S*s was between the Continuous Work and Problems + Task conditions. For the low-ability *S*s the only significant difference was between the Other Problems and Problems + Conversation conditions. Thus, in terms of evidence for incubation, only one condition for one group of *S*s resulted in significantly more solutions than Continuous Work: the Problems + Task condition for the high-ability *S*s.

DISCUSSION

The primary goal of this study was to demonstrate incubation effects in an experimental setting. This goal was reached, but only under very limited circumstances. The only condition that resulted

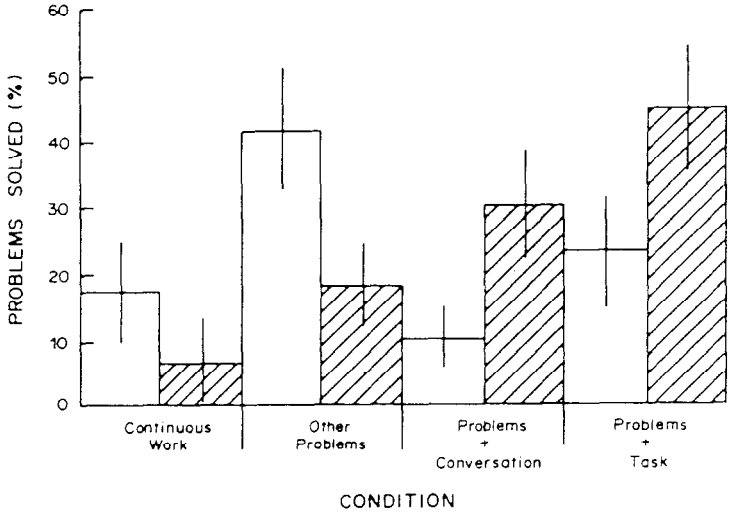

Fig. 1. Mean percentage of problems solved for high- (▨) and low-ability (□) *S*s in four conditions. The vertical lines represent the standard errors of the means.

in more solutions than Continuous Work was when the high-ability *S*s were interrupted by other problems and the rotations task. This suggests that incubation may be a very elusive phenomenon that only occurs for high-ability *S*s under the right conditions.

The fact that the present study showed any incubation effects is important in light of all the failures that have been reported. This study was run under conditions thought to be most conducive to witnessing incubation effects and the particular factors that might be necessary for incubation still need to be examined. In particular, the factors suggested here of ensuring the *S*s are 'stuck' on the problems, using a sensitive dependent variable and providing multiple interruptions need to be investigated further.

The finding that only the high-ability *S*s benefitted from the interruptions is directly contradictory to the results reported by Murray and Denny (1969). In that study only the low-ability *S*s benefited from an interruption while the high-ability *S*s were actually hindered. There are a number of possible reasons behind the contradictory results. First, the two studies used different problems to test for incubation effects. Murray and Denny used an insight problem that required determining alternative uses for common objects, while the RAT requires generation of remote associates and convergence on a single solution. Perhaps the differences between these types of problems are important for determining the role that ability plays in incubation effects.

As mentioned previously, a second difference between the studies is that the present study used a direct measure of problem-solving ability while Murray and Denny did not. It would appear, then, that the present study involves a more accurate measure of ability level, but the use of measures like the GTT has not been examined in detail.

The results of the present study also make more sense on an intuitive basis. Recall that Murray and Denny (1969) interpreted their results as suggesting that the low-ability *S*s may be 'fixated' on certain responses, while the high-ability *S*s were working productively when the interruption was introduced. This may have been the case in their study since Murray and Denny (1969) did not ensure that their *S*s were 'stuck' on the problems before the interruption was introduced. In the present study steps were taken to ensure all the *S*s were stuck on the problems and thus it is difficult to argue that an interruption only serves to disrupt the ongoing work of the high-ability *S*s. In fact, the low-ability *S*s solved slightly more problems than the high-ability *S*s in the Continuous Work condition.

Further, Murray and Denny (1969) extended their results by suggesting that creative people who report incubation phenomena are like their low-ability *S*s who are fixated. It seems more reasonable to suggest that creative thinkers are more like high-ability *S*s who are very good at a task, but when stuck can benefit from an interruption. Low-ability *S*s, however, may only be distracted by an interruption if it is unrelated to the problem of interest. It is interesting to note that in the present study the low-ability *S*s solved the most number of problems when they were interrupted to work only on other problems. This suggests that these *S*s can benefit from more experience with the same types of problems.

It also remains to be determined why only one of the interruption conditions (Problems + Task) resulted in significantly more problem solutions than Continuous Work. It could be argued that this condition provides an interruption that gets the *S*s 'far away' from the problems to be solved. Perhaps this interruption allows the *S*s to make a 'fresh start' upon returning to the problem, and this results in increased performance. The only study that directly tested this 'fresh start' or set-breaking hypothesis is a dissertation by Silveira (1972). She collected verbal protocols while *S*s attempted an insight problem under continuous work or interrupted conditions. She then analysed the protocols for perseveration on old ideas to get an indication of mental set and found a great deal of perseveration before an interruption, but this was not affected by the interruption, even for those interruptions that were beneficial for problem-solving. This suggests that set-breaking may not be important for incubation effects, but more research along these lines is needed [see Weisberg and Alba (1982) for a discussion of the similar issues of 'fixation' and 'insight'].

In conclusion, while incubation effects may be very elusive in the laboratory, the faults in the research reported to date make a conclusion that incubation does not exist premature. Many factors that might be conducive or necessary for incubation effects have not been tested, and in this paper I have suggested a few factors that should be investigated: the sensitivity of the dependent measure, ensuring that the *S*s are 'stuck' on the problems before the interruptions are introduced,

the use of multiple interruptions to mimic real-life work conditions, and the nature of the interrupting activity. However, the most interesting factor might be the ability level of the *S*s for the task involved: high-ability *S*s may show incubation effects while low-ability *S*s may not.

Acknowledgement—I would like to thank Lee Brooks for his advise and support, and Albert Katz for his helpful comments on an earlier draft of the manuscript.

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