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Authors

McCarthy, Sean
Malony, John
Morrison, Robert

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Insight Follows Incubation In The Compound Remote Associates Task

Sean W. Mc Carthy (smccartesol@gmail.com)

Department of Psychology
Loyola University Chicago
1032 W Sheridan Rd
Chicago, IL 60626 USA

John M. Malony (jmalony@luc.edu)

Department of Psychology
Loyola University Chicago
1032 W Sheridan Rd
Chicago, IL 60626 USA

Robert G. Morrison (rmorrison@luc.edu)

Department of Psychology, Neuroscience Institute
Loyola University Chicago
1032 W Sheridan Rd
Chicago, IL 60626 USA

Abstract

The phenomenon of insight is frequently characterized by the experience of a sudden and certain solution. Anecdotal accounts suggest insight frequently occurs after the problem solver has taken some time away from the problem (i.e., incubation). Here we used Compound Remote Associates problems to examine how incubation affects the subjective experience of insight at different levels of problem fixation. We hypothesized that incubation would elicit a mind-set change resulting in improved problem solving performance regardless of the initial level of fixation. Second, we predicted to the extent that insight reflects a person's assessment of mind-set change, the experience of insight would be more likely after incubation. Results were consistent with these predictions. These findings suggest that the role of incubation in producing insight may have more to do with changing mind-set than forgetting information that fixates problem solvers.

Keywords: creativity; fixation; incubation; insight; problem solving

Introduction

People frequently describe solving problems with either an analytic, step-by-step process, or a comparatively unconscious process resulting in unexpected answers (Boden, 1994; Morrison, in press; van Steenburgh et al., 2012). In the latter situation people show little ability to predict their sudden insight (Metcalfe, 1986), yet have great confidence in the solution that seemingly came from unconscious processing (Simonton, 2012; Smith & Ward, 2012). This experience often follows a time away from the problem, also known as incubation (van Steenburgh, et al., 2012).

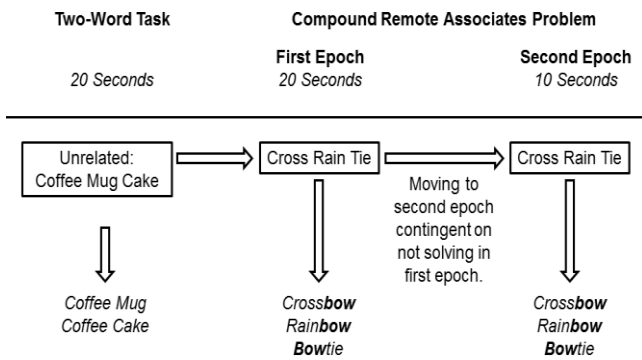
Insight has been studied using a variety of different approaches. Beginning with the Gestalt psychologists, researchers attempted to create problems where the experience of insight was more likely (e.g., Duncker's (1945) Candle Problem; Katona's (1940) Matchstick Arithmetic Problems; Mednick's (1962) Remote Associates Problems). Using these types of problems researchers have examined the experience of insight, for instance by asking participants to monitor their problem solving progress *in situ* (Melcalfe, 1986) or asking participants to report whether they experienced insight upon problem completion (Bowden & Jung-Beeman, 2003a). The latter approach allows researchers to make *post hoc* comparisons between problems solved with and without insight on a problem-by-problem basis for each participant.

Alternatively, some studies have examined how problem-solving context could facilitate insight solutions (e.g., Barid et al., 2012; Kounios et al., 2008; Smith & Blankenship, 1991; Storm, 2010, 2011; Wallas, 1926). For instance, Smith and Blankenship (1989) argued that incubation allows problem solvers to forget (or perhaps inhibit) mental representations resulting in fixation and thereby achieve an insight solution.

The role of incubation in promoting insight

Building on an earlier study by Smith and Blankenship (1989), Kohn and Smith (2009) asked participants to solve remote associates problems (Mednick, 1962) in which participants must discover a single word that is a remote associate of three different words. Prior to attempting to solve each problem participants completed an initial task

(a) Unrelated – Direct Conditions



(b) Blocking - Incubate

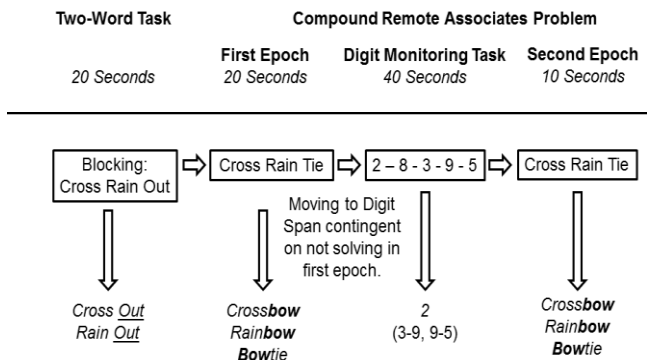


Figure 1: (a) *Unrelated – Direct* and (b) *Blocking – Incubate* example trials. In *Unrelated* Compound Remote Associates (CRA) trials the preceding Two Word Phrase Task (TWPT) problem has no words in common with the CRA problem while in *Blocking* CRA trials the preceding TWPT problem contains two of the CRA problem words which pair with a third word that is not the correct answer for the CRA problem, thereby increasing CRA problem fixation. In *Direct* CRA trials participants have two contiguous epochs to try to solve the CRA problem, while in *Incubate* CRA trials the two epochs are separated by a 40 s incubation period in which participants perform the Digit Monitoring Task (DMT).

designed to manipulate the level of fixation experienced while trying to solve the remote associates problems. Participants briefly tried to solve each remote associates problem and then were given either a second continuous solution period or a brief 30s incubation period during which they performed a working-memory distractor task. Kohn and Smith found a trend towards participants showing an improvement in performance for problems on which they were initially more fixated and received an incubation period. Using a different type of insight problem, Baird and colleagues (2012) also found a benefit for incubation; however, the greatest benefit was found not from a difficult distractor task or simple rest during incubation, but rather from a task designed to promote mind-wandering. This latter result suggests that the benefit of incubation may not be to help participants overcome fixation, but rather, to promote the appropriate cognitive processing conducive to insight. Likewise, sleep studies by Cai and colleagues (2009) demonstrated that implicit priming of answers to unsolved Remote Associates Problems helped participants solve the problems after REM sleep compared to non-REM sleep or an equivalent rest period. This result suggests that time alone is insufficient for incubation effects, but rather solutions involving insight require a change in the underlying cognitive processing used for problem solving. However, none of these studies specifically asked participants whether they had experienced insight while solving the problem.

Bowden and Jung-Beeman (2003a) developed a subjective measure of insight for use with Compound Remote Associates problems (CRA; Bowden & Jung-Beeman, 2003b) variants of Mednick’s (1962) classic Remote Associates Task problems. Specifically Bowden and Jung-Beeman (2003a) asked participants after they had

solved a CRA problem to report via a numeric scale, how much insight they had experienced. Jung-Beeman and colleagues (Bowden & Jung-Beeman, 2003b; Jung-Beeman et al., 2004; Kounios et al, 2006, 2008) have used various versions of this methodology to perform *post hoc* sorting of problems based on the participant’s subjective experience. Using this methodology along with various neuroimaging methods they found evidence that right anterior superior temporal gyrus, a brain area associated with semantic integration, was specifically engaged just prior to CRA problems that participants reported solving with insight (Jung-Beeman, et al., 2004). Importantly, they also found evidence for neural activity indicative of visual gating just prior to the right temporal activity suggesting that a part of solving with insight might involve inhibiting the external world in favor of subconscious processing. Likewise, Kounios and colleagues (2008) identified this same neural signature before participants had initially seen problems they subsequently reported solving with insight, suggesting that the visual gating was likely indicative of a different problem solving strategy (Kounios et al., 2008).

Current Study

The purpose of this study was twofold. First we wanted to explore whether taking time away from a problem (i.e., incubation) contributes to the subjective experience of insight. Second, to investigate whether incubation specifically helps participants overcome fixation, we adapted Kohn and Smith’s (2009) paradigm for use with CRA problems (Bowden and Jung-Beeman, 2003b) and a subjective measure of insight. Specifically, we used Kohn & Smith’s two-word task to manipulate the degree of fixation prior to attempting to solve a CRA problem. We then manipulated incubation by either giving participants a second immediate opportunity to solve the problem, or

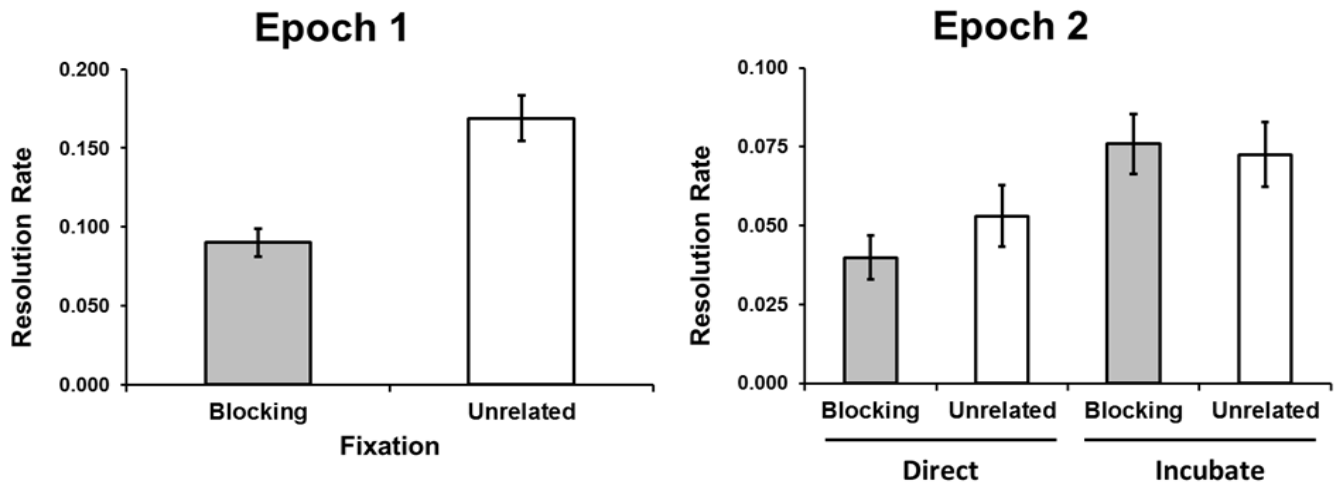


Figure 2: In Epoch 1, there was a reliable effect of blocking on CRA resolution rates demonstrating the effectiveness of the TWPT problem fixation manipulation. In Epoch 2, there was a reliable effect of incubation, with no interaction with initial TWPT induced fixation. Error bars represent ± 1 SEM.

instead gave them a period of incubation where they performed a working-memory distractor task. Whenever participants solved CRA problems, they were asked to report whether they experienced insight or not. This procedure thus allows us to evaluate whether insight is more likely after incubation and whether insight solutions were likely the result of release from problem fixation.

We hypothesized that incubation with a mild working-memory distractor would elicit a mind-set change resulting in improved CRA problem solving performance regardless of the initial level of fixation. Second, we predicted that if the experience of insight reflects a person's assessment of mind-set change they would report greater insight on successfully solved problems after incubation than if they simply continued working on the problems without an incubation period.

Method

Participants

Eighty undergraduate students (60 female) from Loyola University Chicago participated in the experiment. Participants gave informed consent to take part in the study. The Loyola University Chicago Institutional Review Board approved all recruitment methods and procedures.

Task Descriptions

Three tasks implemented in e-Prime 2.0 were used in this experiment. The primary task consisted of Compound Remote Associate problems (CRA; Bowden & Jung-Beeman, 2003b). Each CRA problem consists of three unrelated words that can each be paired with a fourth target word that is a remote associate of each of the cue words to

make three compound word pairs (see Figure 1 for an example problem).

After the methods of Kohn and Smith (2009), we manipulated CRA problem fixation through use of a preceding Two-Word Phrase Task (TWPT) problem corresponding to each CRA problem. This task required participants to combine three presented words, two of which were from the corresponding CRA problem, into two two-word phrases (see Figure 1). This was intended to create a strong association for two of the CRA words to a word that was not the correct CRA answer, and thereby induce CRA problem fixation. We used the corresponding TWPT problem before the CRA problem in the *Blocking* condition (see Figure 1b), while we used an unrelated TWPT problem created for a different CRA problem in the *Unrelated* condition (see Figure 1a).

Lastly, we used a Digit-Monitoring Task (DMT; Kohn & Smith, 2009) as the distractor task during incubation. In the DMT participants saw a series of digits from 1 to 9 presented one digit each second for 40s. Participants were to track the total number of times that two odd digits were presented in a row and report that at the end of the incubation period.

Testing Procedure

Forty-four CRA problems were rotated between four counterbalanced conditions (i.e., Unrelated/Direct, Unrelated/Incubate, Blocking/Direct, Blocking/Incubate; see Figure 1 for a schematic of two of the conditions). Each trial began with a TWPT problem for 20s followed by a CRA problem. On Direct trials if the participant did not solve the CRA problem in 20s (Epoch 1) they were given 10 additional seconds to solve the problem (Epoch 2). On Incubate trials that they did not solve in 20s they performed the DMT for 40s and then were given an additional 10s to solve the CRA problem. To encourage

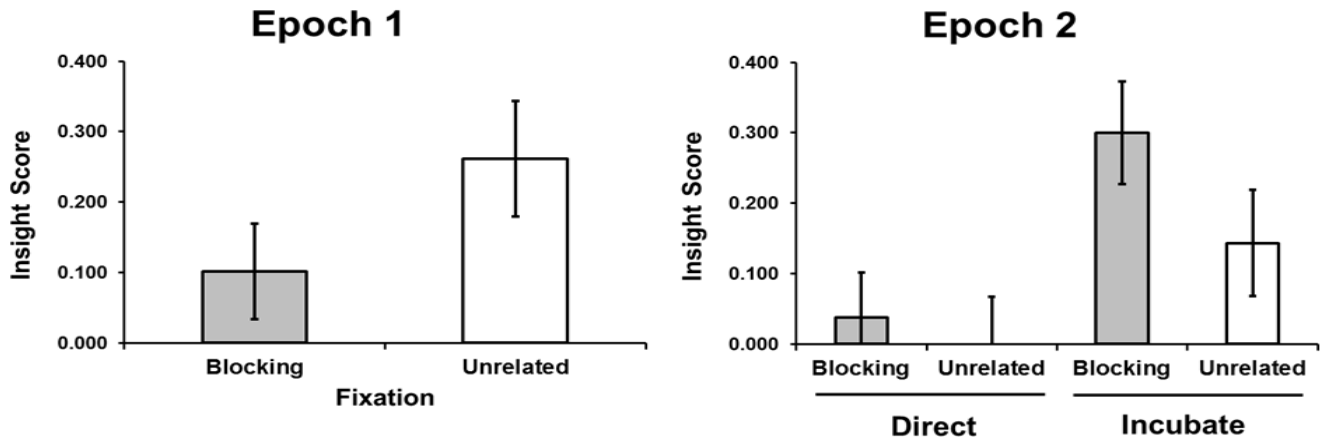


Figure 3: In the first epoch, reports of insight were significantly higher in the unrelated condition suggesting that overcoming fixation was not responsible for the experience of insight. In the second epoch reports of insight were greater following incubation suggesting that the incubation task helped participants to elicit a mind-set change resulting in an insight solution. Error bars represent ± 1 SEM.

participants to form links between the TWPT and the CRA problems we used 6 additional CRA problems in the *Helping* condition. In these problems the correct answer for the CRA problem was given as the third word in the TWPT problem.

The definition of insight given to subjects was taken from Jung-Beeman et al. (2004). Briefly, the feeling of insight was described as a sudden experience in which a fully formed answer came to mind all at once. Upon solving a CRA, subjects were asked if they experienced insight. The subjects responded verbally with either yes or no.

Results

Due to the CRAs being divided into a first 20s epoch and a second 10s epoch, accuracy was calculated using resolution rates (Kohn & Smith, 2009). For the first epoch the Resolution rate was simply equal to the proportion solved correctly. For the second epoch we corrected for the number of problems solved in the first epoch and used the number of problems attempted during the second epoch as the denominator in the proportion correct calculation.

Resolution rate in the first epoch was impacted by fixation with participants solving more problems when they were preceded by a TWPT that did not result in greater fixation (see Figure 2; $t(79) = 5.6$, $p < .001$). Next we evaluated whether performance in Epoch 2 was impacted by incubation and whether this interacted with our fixation manipulation. A two-way within subjects ANOVA yielded a main effect of incubation (see Figure 2; $F(1,79) = 11.5$, $p = .001$, $\eta_p^2 = .13$), but no main effect of fixation $F(1,79) = .48$, $p = .5$, $\eta_p^2 = .006$ and no interaction $F(1,79) = .73$, $p = .4$, $\eta_p^2 = .009$). Following the analysis of Kohn and Smith (2009) we also performed planned comparisons to look at the effect of incubation on *Blocking* and *Unrelated* trials independently. As in Kohn

and Smith's study participants showed a reliable difference in CRA resolution rate with respect to incubation in the *Blocking* condition ($F(1,79) = 12.0$, $p = .001$, $\eta_p^2 = .13$). However, unlike Kohn and Smith we found a trend towards a difference for the unrelated condition as well ($F(1,79) = 2.8$, $p = .10$, $\eta_p^2 = .03$), consistent with our failure to find a reliable interaction between incubation and fixation. Thus, overall our results suggest that incubation aided in CRA problem solving regardless of the level of fixation as manipulated by the TWPT.

Overall, 62% of all correct answers were answered with insight and 38% were answered without insight. In an effort to measure participant's subjective experience of insight within each condition, we calculated an insight score for each participant by subtracting total number of correct non-insight answers from their total number of correct insight answers and dividing by the resolution rate.

Insight score in the first epoch was impacted by fixation with participants reporting greater insight on solution when they had less fixation as manipulated by the Two-Word Task (see Figure 3; $t(79) = 2.6$, $p = .012$). Next we evaluated whether the experience of insight in Epoch 2 was impacted by incubation and whether this interacted with our fixation manipulation. A two-way within subjects ANOVA yielded a main effect of incubation (see Figure 3; $F(1,79) = 9.0$, $p = .004$, $\eta_p^2 = .10$), but no main effect of fixation $F(1,79) = 2.3$, $p = .14$, $\eta_p^2 = .03$ and no interaction $F(1,79) = .78$, $p = .4$, $\eta_p^2 = .01$). Our results suggest that incubation increased the experience of insight, just as it aided solution performance. Likewise, the experience of insight does not appear to be majorly impacted by the initial degree of problem fixation.

Discussion

Using a similar incubation and fixation paradigm with different remote associates problems, Kohn and Smith

(2009) reported that incubation led to higher resolution rates when participants were subjected to a task intended to cause problem fixation. They suggested that this improvement was due to distraction during incubation helping participants overcome problem fixation by forgetting wrong associations. In our study, we found that in spite of a strong initial fixation effect, incubation helped participants solve problems regardless of the level of fixation. In addition, participants experienced greater insight when they successfully solved problems after incubation regardless of fixation compared to when they successfully solved problems in a continuous period (Direct condition). Our results suggests that incubation does contribute to the experience of insight, and that incubation likely contributes to insight problem solving in ways other than just through forgetting fixation.

Recently Baird and colleagues (2012) presented evidence suggesting that what people do during incubation affects how likely they are to solve insight problems. Importantly, they found that a more demanding task resulted in less improvement than a less demanding task that encouraged mind wandering. Likewise, Cai and colleagues (2009) found that when participants experienced REM sleep during a Remote Associates Task incubation period they were more likely to benefit from an implicit semantic clue prior to incubation than if they had non-REM sleep or simply rested during incubation. Like our results, these findings suggest that something more than just forgetting must occur during incubation to facilitate insight.

One possible role for incubation may be to shift the mood of the participant. In our study when participants solved CRA problems during the first epoch prior to incubation they reported less insight when they had previously solved a TWPT problem intended to create CRA problem fixation than when they solved an unrelated TWPT problem (see Figure 3 Epoch 1). It is possible that the frustration resulting from fixation may encourage a negative mood. Several previous studies have suggested that participants are more likely to solve insight problems when they are in a positive mood (e.g., Isen, Daubman, & Nowicki, 1987; Subramaniam et al., 2009). Subramaniam and colleagues showed that when people were high in self-reported positive affect prior to testing they were more likely to solve CRA problems and report insight. Van Steenburgh and colleagues (2012) have speculated that this effect of positive affect may be due to the ability of positive affect to encourage a broadening of attention (see also Rowe, Hirsch, & Anderson, 2007). A broad attentional focus has long been known to be associated with creative behavior (e.g., Ansburg & Hill, 2003; Mendelsohn & Griswold, 1966). While it seems unlikely that performing the DMT incubation task in the present study would likely elicit a positive mood it is possible that the shift away from being stuck on a problem may result in at least a less negative mood perhaps resulting in a broader attentional mindset.

While our findings do support the idea that incubation can contribute to a change in mindset that aids in solving problems with insight, much remains to elucidate the precise nature of cognitive change that occurs during incubation.

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