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Mechanisms underlying incubation in problem-solving: Evidence for unconscious cue assimilation

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Abstract

Two experiments tested whether spreading activation or cue assimilation underlie incubation effects in problem solving. After initial attempts to solve remote associates tasks, participants performed lexical decision tasks that included solution words, and attempted the remote associates again, either immediately, after a delay with no interpolated task, or after a delay with filler tasks. Spreading activation of target lexical items was not influenced by incubation. However, the presence of solution words in interpolated lexical decision items gave rise to incubation effects with high cognitive-load incubation tasks. The results support a cue-assimilation process, in which unconscious processes access solution relevant information during incubation, but only if conscious task activity is suppressed. It is suggested that different mechanisms may occur during an incubation period to facilitate solution finding, depending on the nature of the impasse encountered during initial attempts.

Keywords: Incubation; Cue-assimilation; Spreading-activation; Problem Solving

Introduction

Incubation arises when the solution to an unsolved problem comes to mind after a temporary shift of attention to other domain. The phenomenon is well-documented in anecdotal reports of the intellectual discovery processes of geniuses (e.g. Wallas, 1926; Ghiselin, 1985), and its existence was confirmed by Sio and Ormerod (2009) in a meta-analysis of past incubation studies. Two hypotheses have been proposed to account for this seemingly discontinuous and effortless problem-solving process. The *conscious-work* account suggests that incubation helps individuals recover from mental fatigue or provides extra time for additional problem solving (Browne & Cruse, 1988; Posner, 1973). The *unconscious-work* account suggests that incubation filler tasks force individuals to give up active control on the problem, and this facilitates gradual, unconscious problem-solving processes.

The conscious-work account predicts that an unfilled incubation period generates a larger incubation effect than a filled one, while the unconscious-work account makes the opposite prediction. Neither account receives unequivocal empirical support: some studies show that participants who had a filled incubation period outperformed those who rested or worked on the problem continuously (e.g., Patrick, 1986; Penney, et al., 2004; Smith & Blankenship, 1989). Others report the opposite: participants who rest during an incubation period perform better than those who had to perform tasks during an incubation period (Browne & Cruse, 1988). Other studies report the same level of performance by participants with filled and unfilled incubation periods (Olton & Johnson, 1976). Sio & Ormerod (2009) found that different procedural moderators affect incubation, but their meta-analysis provided more support for the unconscious work hypothesis, although effects are specific to particular problem types. With linguistic insight problems such as remote associates tasks (RATs), light-load tasks yield a stronger incubation effect than rest or heavy load task. It is suggested that light load incubation tasks divert individuals' attention to other areas, and this facilitates helpful unconscious processes. However, with visual problems, incubation task load has no impact.

Three proposals for unconscious processes are spreading activation (Smith, 1995; Yaniv & Meyer, 1987), selective forgetting (Smith, 1995; Smith & Blankenship, 1991), and opportunistic assimilation (Seifert et al., 1995). The spreading activation hypothesis holds that during the incubation period activation spreads to relevant memory items. Partially activated items may combine or interact with external cues to yield fortuitous insightful ideas. The selective-forgetting hypothesis (Simon, 1966; Smith, 1995; Smith & Blankenship, 1991) holds that an incubation period provides time to forget over-activated irrelevant concepts/strategies, and this allows a fresh view of the problem. The opportunistic-assimilation hypothesis (Seifert et al, 1995) emphasizes the role of initial failure in the incubation effect, suggesting that impasse encountered at the initial approach helps individuals to re-encode the problem in a form that increases of the likelihood of assimilating any cue encountered by chance.

Experimental paradigms of past incubation studies have not discriminated between specific hypotheses. The settings of the past incubation studies are fairly uniform: one group of participants is interrupted with a break filled with other tasks while solving the problem, whereas the other group works on the problem continuously. This design cannot determine what type of unconscious process underlies performance improvements in incubation conditions. The experiments reported in this paper use a lexical decision task (LDT) introduced by Sio and Rudowicz (2007) to assess sensitivity towards relevant memories before and after an incubation period. Sio and Rudowicz found an increase in sensitivity after incubation period, although they did not investigate whether an incubation effect also arose. If spreading-activation is the source of incubation effects, then enhanced solutions to problems should be accompanied by decreased lexical decision latencies to solution-relevant words. The presentation of LDTs containing solution-relevant words could also serve as a relevant cue to the problem, and this can be adapted for testing the opportunistic–assimilation hypothesis. According to the opportunistic-assimilation hypothesis, individuals who receive relevant cues (presentation of the LDTs) after an incubation period should outperform those who receive cues in a no-incubation condition or those who do not receive any cue after the incubation period.

Experiment 1

Method

Participants

48 (F: 37, M: 11) undergraduates from Lancaster University were recruited. The mean age was 19.33 (*SD*=1.48).

Design

Participants were randomly assigned to one of three conditions; immediate re-presentation of unsolved RATs, a rest period between initial and repeated attempts, or an incubation period filled with unrelated tasks. Participants in each group were further assigned to one of two groups receiving different sets of RATs matched for similar levels of difficulty, to check that effects are not item-specific.

Materials

Remote Associates Tasks (RATs; Mednick, 1962) were used as the problem-solving task in this study. In each RAT, three apparently unrelated words are presented, and participants have to think of a fourth word that forms an association with each of the three words. For example, if the three stimulus words of a RAT are "blue", "cake" and "cottage", the fourth word can be "cheese". 16 RATs were selected from a pool created by Bowden and Jung-Beeman (2003). The RATs were randomly divided into two sets, Set A & B. The reported solution rates ranged between 10%-31%, with a mean of 17.75 (*SD* = 6.32) for Set A, and 22.63 (*SD* = 8.18) for Set B. The mean solution rate between these two sets was not significant, $t(15) = 1.33$, $p = .20$.

Lexical Decision Tasks (LDTs) were adapted to examine participants' level of sensitivity to relevant solution concepts. A set of LDTs, consisting of five items including neutral words, pseudo-words, and the answer of the unsolved RAT (target words), was presented after each initial attempt at a RAT. All presented words were high frequency words (an occurrence of 90 or more in a million).

Mental rotation tasks (MRTs) and arithmetic tasks (ATs) were used as incubation tasks. Each MRT consisted of a pair of objects. Participants had to judge if the objects in each pair were identical. The ATs comprised three-digit additions and subtractions.

Procedure

Experiment 1 was run on a computer using bespoke software. In the presentation of each RAT, participants had to speak out their answer to a microphone connected to a tape-recorder. When solving MRTs and LDTs, participants entered their responses via the keyboard. The latency and responses given by participants were recorded. Latency was measured from the onset of the stimulus until the participants responded. When solving ATs, participants wrote down their answers on a sheet of paper.

In each set of experimental trials, 8 RATs were presented in the same sequence for each participant. In each trial, the three stimulus words of the RAT were presented horizontally across the centre of the screen at the same time. Participants had 30 seconds to solve the RAT after it was presented, and could respond at any time by pressing the C key, after which they spoke out their answer, and then pressed the C key again. In the Immediate Condition, participants were prompted to do an LDT set followed by a second attempt to the RAT, or vice versa depending on whether it was an LDT-before (the 1st, 2nd , 5th , and 8th RATs) or LDT-after (3rd , 4th , 6th , and 7th RATs) trial, immediately after completion of their first attempt at the RAT. In the Rest Condition, participants were prompted to sit quietly and listen to soft music for two minutes before proceeding to complete the LDT set or the same RAT. In the Incubation Condition, participants were prompted to complete MRTs for one minute and ATs for another minute (incubation period) before proceeding to complete the LDT set or the same RAT. Figure 1 presents the task sequence in each condition.

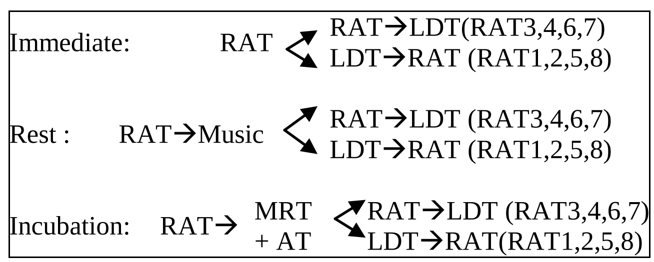

Figure 1: Task presentation sequence in each condition

The five items in each LDT set were presented at the centre of the screen, one at a time. Before presenting each stimulus, a fixation cross was presented at the centre of the screen for 1 second to draw participants' attention. The first presented item was always a neutral word or pseudo-word, which served as a warm-up stimulus. The target word, along with pseudo-words and neutral words, was counter-balanced across the remaining four positions.

Results and Discussion

If incubation tasks facilitate the proposed unconscious problem processes, participants in the Incubation condition should perform better than participants in the other conditions. Also, they should be more sensitive to the target words if spreading activation occurs. The opportunistic-assimilation hypothesis predicts that participants who were in the Incubation condition and received cues before re-approaching the RAT had largest performance improvement.

Opposite to these, the conscious-work account predicts that participants in the Rest condition would outperform participants in other conditions in RAT solving.

Performance Improvement

To test for the presence of incubation effects, participants' performance (number of correct responses) in solving the 3^{rd}, 4^{th} ,6^{th}, and 7^{th} RATs were compared across the three conditions (see Table 1 for the *M* and *SD* in each condition).

Table 1. *Ms* and *SDs* (in parenthesis) of the number of correct responses in the two by Condition and Question Set

	Set A	
	First	Second*
	M (SD)	*M (SD)*
Immediate	.33 (1.00)	1.00 (1.32)
Rest	.43 (.53)	.43 (.53)
Incubation	.57 (.53)	.57 (.53)
	Set B	
	First	Second
	M (SD)	*M(SD)*
Immediate	.89 (.78)	.89 (.78)
Rest	1.00 (1.60)	1.38 (1.69)
Incubation	.50 (.53)	1.00 (.53)

*Number of correct responses in the 2^{nd} attempt = number of items solved in the 1^{st} attempt + number of items solved in the 2^{nd} attempt.

A 3(Condition) x 2(Time) x 2(Question Set) ANOVA with repeated measures on Time (1^{st} vs 2^{nd} attempts), using number of correct responses to RATs as DV, was carried out. The Question Set effect was not significant, p = .17, showing that the number of solved RATs in set A and B was comparable. The Time effect was not significant, p =*.63*, implying that there was no performance improvement in the 2^{nd} attempt. This pattern of performance was found in all the conditions, indicated by the non-significant Time x Condition effect, $p < .58$.

Spreading Activation

Although no incubation effect on the performance level was found, it is still possible that spreading-activation occurred during the incubation period to sensitize participants to relevant knowledge. To examine this possibility, participants' sensitivity to relevant memory items in each condition (the lexical latency for the target words of the 1^{st}, 2^{nd}, 5^{th} , and 8^{th} RATs), was examined. Incorrect lexical decisions, and correct decision with extreme lexical decision time (< 50 or >2500 ms) were discarded as outliers (2.6%). The lexical decision time was then log-transformed for diminishing skew. Table 2 presents the M and SD of the lexical decision time for neutral and target words in each sub-group.

Table 2. *Ms* and *SDs* (in parenthesis) of the lexical decision time on neutral and target words by Condition and Question Set

	Immediate	Rest	Incubation
	Neutral Words		
Set A	675.9 (181.5)	695.7 (204.4)	741.0 (197.7)
Set B	839.8 (203.7)	832.7 (232.1)	804.6 (192.4)
	Target Words		
Set A	725.7 (166.5)	652.2 (83.5)	736.1 (189.5)
Set B	841.8 (336.1)	728.7 (221.8)	737.5 (203.4)

A 2 (Word Type) x 2 (Question Set) x 3 (Condition) ANOVA with repeated measures on Word Type (Neutral vs Target), using lexical decision times as DV, was carried out. None of the main and the interaction effects was significant, implying that participants' lexical decision times for target and neutral words were comparable among the three conditions. This suggests that participants in the Incubation Condition were not more sensitized to target words.

Opportunistic Assimilation

To examine the opportunistic-assimilation hypothesis, participants' performance improvement score (number of newly solved item in the 2^{nd} attempt / number of unsolved items in 1^{st} attempt) in the 1^{st} , 2^{nd} , 5^{th} , and 8^{th} RATs (LDT-after: no Cue) and 3^{rd} , 4^{th} , 6^{th} , and 7^{th} RATs (LDT-before: Cue) were compared (see Table 3 for *M*s and *SD*s).

Table 3. *M*s and *SD*s (in parenthesis) of the Improvement Score by Condition and Question Type and Presence of Cue

	Cue	No-Cue	Difference
	M (SD)	*M (SD)*	*(cue-no cue)*
	Set A		
Immediate	.16(.20)	.25 (.33)	-.07
Rest	.18(.24)	. 0(0)	.18
Incubation	.04 (.09)	. 0(0)	.04
	Set B		
Immediate	.14 (.32)	0 (0)	.14
Rest	.14 (.20)	.21 (.37)	-.07
Incubation	.09 (.19)	.13 (.15)	-.04

To examine the opportunistic-assimilation hypothesis, a 2(Question Set) x 2(Cue) x 3 (Condition) ANOVA with repeated measures on Cue (no Cue vs Cue), using improvement score as DV, was carried out. If the incubation period facilitated cue-assimilate, then a significant Cue x Condition effect is expected. Yet, the main and interaction effects of these two factors were not significant, suggesting that participants in the Incubation condition were not more likely to assimilate the cues. This is not in line with the opportunistic-assimilation hypothesis.

Experiment 2

Experiment 1 failed to demonstrate an incubation effect, but this null effect may be related to the difficulty of the RATs used, reflected in the low number of correct responses. An incubation period might not be helpful if the problems are so difficult that individuals do not have the required knowledge to solve it. Also, consistent failures in problem solving may lower problem solvers' motivation, and in turn, affect their performance.

Experiment 2 was conducted to replicate Experiment 1 using easier RATs, and to examine the link between the loading of the incubation tasks and the incubation effect. The paradigm of Experiment 2 was similar to the one in Experiment 1, except having two modifications. First, there was an adjustment on the difficulty of the RATs. In Experiment 2, easier RATs were selected from the RAT pool given by Bowden and Jung-Beeman (2003). Two sets of RATs were prepared, an Intermediate set (solution rate: 25.5%-45%) and an Easy set (solution rate: 55%-75.5%). There was no Rest condition, but two Incubation conditions were run, with incubation periods filled by either high- or low-load tasks. The Immediate condition remained the same as in Experiment 1 and served as a control condition.

Method

Participants

81 (F: 69, M: 12) undergraduates from Lancaster University were recruited, and the mean age was 19.61(*SD*= 1.73).

Materials

MRTs and ATs were again used as incubation tasks. The MRTs used in Experiment I were divided into two sets, the High- and Low-Load sets, based on participants' MRT performance (response time and correct rate) in Experiment I. High-Load MRTs were those with below-average correct rate and shorter-than-average response time, and Low-Load MRTs were those with above-average correct rate and longer-than-average response time. The mean response time and correct rate of the selected MRTs was 5.70 (*SD* = .90), and 52.87% (*SD* = 9.59) in High-Load Set, and 3.17 (*SD* =.55) and 77.52 % (*SD* = 10.33) in Low-Load Set. The differences on response time and correct rate between these two sets were significant, response time: $F(1, 53)=158.50^{**}$, $p < .001$; correct rate: $F(1, 53) = 83.94^{**}$, $p < .001$. Two sets (High- and Low-Load) of ATs were also prepared. The High-Load ATs were 3-digit summations and subtractions with regrouping. The Low-Load version included 3-digit summations and subtractions without regrouping. During the incubation period, 5 MRTs (8 second each) and 8 ATs (10 second each) were presented.

Procedure

Participants were randomly assigned to solve either the easy or intermediate RATs in one of the conditions. The procedure and the presentation of the tasks in Experiment II were identical to those used in Experiment I.

Results and Discussion

According to the unconscious-work account, participants in the incubation conditions should perform better than participants in other conditions, and the enhanced performance should be accompanied by the occurrence of unconscious processes. The meta-analysis (Sio & Ormerod, 2009) suggests that the incubation effect in the Low-Load condition would be the largest among the three conditions. The conscious-work account also predicts a larger incubation effect in the Low-Load condition, but with the absence of any proposed unconscious processes. Combining the findings on the performance and cognitive levels allows us to test these two opposite accounts.

Participants' RAT performance was first examined to check: 1) that the RATs in Experiment 2 were indeed easier than those in Experiment I; 2) easy RATs were easier than intermediate RATs. The mean number of correctly solved RATs in the 1^{st} attempt in Experiment 2 (M = 3.1, SD =2.15) was higher than the mean in Experiment 1 (M =.96, SD = 1.25), $t(136) = 7.40$, $p < .001$. The mean number of solved items in the easy RAT set (M = 4.39, SD = 1.99) was higher than the mean in the intermediate RAT set (M= 1.75, SD=1.31), $t(88) = 7.38$, $p < .001$.

Performance Improvement

Correct responses to the 3^{rd}, 4^{th}, 6^{th}, 7^{th} RATs among the three conditions are shown in Table 4. A 3 (Condition) x 2 (Time) x 2 (Difficulty) ANOVA with repeated measures on Time (1^{st} vs. 2^{nd} attempt), using number of correct responses as DV, was conducted. Non-significant effects of Condition x Time, p = .33, and Condition x RAT Difficulty x Time, p =.59, indicate that, in both RAT sets, participants' performance among the three conditions was comparable.

Table 4. *M*s and *SD*s (in parenthesis) of the number of correct responses by Condition and RAT Difficulty

	Easy	
	First	Second *
	M (SD)	*M (SD)*
Immediate	2.16 *(1.46)*	2.42*(1.43)*
Low Load	2.47 *(1.19)*	3.00 *(1.00)*
High Load	2.94 *(.83)*	3.24 *(.83)*
	Intermediate	
	First	Second
	M (SD)	*M(SD)*
Immediate	1.37 *(.96)*	1.47 *(1.02)*
Low Load	.80 *(1.08)*	1.00 *(1.20)*
High Load	.95 *(.84)*	1.23 *(1.07)*

Spreading Activation

Lexical decision times to target words among the three conditions are shown in Table 5. 2.6% of decisions were discarded as outliers.

A 2 (Word Type) x 3 (Condition) x 2 (Difficulty) ANOVA with repeated measures on Word Type (Neutral vs Target), using the log-transformed lexical decision time as DV, was performed. A significant Word Type effect, $F(1,78) = 16.95$, $p < .001$, indicates that participants made quicker lexical decisions to target than neutral words. Non-significant effects of Condition x Time, p =.93, and Condition x Time x Difficulty, $p < .35$, reveal that no differences across conditions and RAT sets. It appears that participants were in general sensitized to the answer of the unsolved problems, but the incubation tasks did not facilitate the spreading-activation processes to further increase the activation level. Thus, the spreading-activation hypothesis is not supported.

Table 5. *M*s and *SD*s (in parenthesis) of the lexical decision time by Conditions and RAT Sets and Word Type

	Neutral Word	Target Word
	M (SD)	*M (SD)*
	Intermediate RATs	
Immediate	694.0 (141.0)	648.7 (154.9)
Low Load	752.6 (153.6)	676.7 (164.2)
High Load	770.0 (137.1)	715.2 (182.9)
	Easy RATs	
Immediate	781.1 (323.0)	770.1 (269.0)
Low Load	707.9 (134.4)	706.4 (382.4)
High Load	799.2 (166.2)	702.5 (166.7)

Although there is no evidence for the spreading-activation hypothesis, it is interesting that there was no dissipation on the activation of the target words even though the participants had shifted attention to other tasks for a while. The persistence of such activation may provide a basis for assimilating any subsequently encountered cues (Yaniv & Meyer, 1987).

Opportunistic Assimilation

To examine if incubation can facilitate the cue-assimilation process, participants' performance improvement scores in solving the 1st, 2nd , 5th , 8th (Cue) and the 3rd , 4th , 6th , 7th (no Cue) RATs were compared. Table 6 presents the *M* and *SD* of the improvement score in each condition. Participants in the Immediate condition were, in general, more likely to solve the unsolved RATs when relevant cues were presented (Easy RAT: .20, Difficult RAT: .18). However, in the Low-Load condition, the presence of cue did not have any positive impact in solving RATs (Easy RAT: -.22, Difficult RAT: .04). In the High-Load Condition, only participants solving Intermediate RATs benefited from the presence of cue (Easy RAT: -.28, Difficult RAT: .16). It seems that the occurrence of cue-assimilation depends on the problem difficulty and the cognitive loading of incubation tasks.

Table 6. *M*s and *SD*s (in parenthesis) of the Improvement Score on the 1st, 2nd, 5th, and 8th RATs (Cue) and 3rd, 4th, 6th, and 7th RAT (no Cue) by Condition and Question Type

	Cue	No-Cue	Difference
	M (SD)	*M (SD)*	(cue-no cue)
	Easy RATs		
Immediate	.34(.44)	.14 (.28)	$.20^{+}$
Low Load	.09(.31)	. 31(.38)	-.22
High Load	.05 (.11)	. 33(.44)	$-.28^{+}$
	Intermediate RATs		
Immediate	.25 (.32)	.07 (.23)	$.18^{*}$
Low Load	.11 (.18)	.07 (.19)	.04
High Load	.24 (.32)	.08 (.17)	$.16^{+}$

$^{*}p < .05$, $^{+}p = .06$,

To examine how these two moderators interact, a 2(Difficulty) x 2(Cue) x 3(Condition) ANOVA with repeated measures on Cue (No Cue vs Cue), using improvement scores as DV, was carried out. As predicted, there was a marginally significant Condition x Cue x Difficulty effect, $F(2, 84) = 4.00$, $p = .05$. To further investigate the interaction, the data were split into three groups, in terms of the experimental conditions. In each group, a 2 (Difficulty) x 2 (Cue) ANOVA with repeated measures on Cue, using improvement scores as DV, was run. A significant Cue x Difficulty effect was found in High-Load Condition, $F(1, 25) = 8.86$, p=.006, revealing that participants solving intermediate RATs benefited more from the cues (Intermediate RAT: .16) than those solving easy RATs (Easy RAT: -.28). This interaction effect was not significant in Low-Load, $p = .14$. The low-load incubation task did not help cue-assimilation as participants did not benefit from the presence of cues (Easy RAT: -.22, Intermediate RAT: .04). This pattern of results supports the opportunistic-assimilation hypothesis, and suggests that problem difficulty and loading of the incubation tasks are the moderators of the cue-assimilation process. The Cue x Difficulty effect was also not significant in the Immediate condition, p= .82. It seems that, in both RATs, participants benefitted from the cues in the same degree. Participants in this condition were actively solving the problem, and thus, it should be easy for them to assimilate the presented cues.

General Discussion

The experiments reported here showed some incubation effects, but only in specific task load and cueing conditions. This outcome is consistent with the findings of Sio & Ormerod's (2009) meta-analysis, which showed incubation to be highly susceptible to task-specific procedural moderators.

The results offer little support for the spreading-activation hypothesis. There was no evidence of increased activation specifically as a result of an incubation period, despite the fact that the LDT was sufficiently sensitive to detect changes in activation of targets relative to neutral words. The absence of spreading activation with incubation contrasts with the finding of Sio & Rudowicz (2007) that an incubation period sensitizes individuals to relevant memory items. This may due to differences in cues used in these two studies. Sio & Rudowicz found spreading activation during the incubation period when solving RATs containing misleading cues. It is possible that the spreading activation occurs only when irrelevant memory items are over-activated. In the current study, the RATs were neutral, and thus may not have fixated individuals to misleading concepts, thereby reducing the influence of spreading activation. It may be that, if misleading cues are provided, then incubation effects may be found, and this possibility is currently under test. It remains unclear whether such effects would best be interpreted as the result of activation of relevant knowledge or selective forgetting of irrelevant knowledge.

In Experiment 2, the presentation of relevant solution cues, in the form of an interpolated LDT, gave rise to incubation effects. However the effect was limited to solving intermediate RATs, and it occurred in the High-Load condition but not in the Low-Load condition, even though participants in both incubation groups were sensitized to the answers of the unsolved problem. This result suggests a link between incubation period and the cue-assimilation process. Participants were sensitized to the answer of the unsolved problem, and the activation persisted even when they shifted the attention to other tasks. This may provide a basis for problem solvers to pick up the external stimuli chance encountered subsequently. However, a cue-assimilation process is not unconditional: its occurrence also depends on the difficulty of the problems and loading of the incubation tasks. One possible explanation is that a partially-activated memory trace is not a sufficient condition for cue-assimilation. In order to assimilate a cue to solve a problem, the problem representation has to be activated when the cue is presented. The high-load incubation tasks may inhibit conscious mental activity that in turn facilitates some unconscious problem solving processes which keeps the mental representation of the unsolved problem activated. The necessity of having an activated representation in cue assimilation can also explain the findings that the positive impact of cues was most significant in the Immediate condition where participants solved the problem continuously. This explanation is, however, opposite to the meta-analysis (Sio & Ormerod, 2009) results that light low cognitive tasks can facilitate unconscious problem solving process. This discrepancy could be related to the incubation condition settings in Experiment 2. In Experiment 2, participants had 8 seconds to solve each MRT. According to the data from Experiment 1, participants took in average about 6 seconds to solve a difficult MRT, and 3 seconds for the easy one. It means that participants in Experiment 2 had more than enough time to solve the incubation tasks. Thus, participants may not have found the High-Load tasks sufficiently demanding, and the incubation period filled with Low-Load task may be indeed more like a rest to them. The High-Load condition in this study may just be equivalent to low cognitive load conditions included in the meta-analysis. To test this hypothesis, we are currently conducting further research with much more demanding incubation tasks.

In conclusion, the findings of this study support the opportunity-assimilation hypothesis, suggesting that incubation tasks help keep the problem representation active, and this allow individuals to assimilate any chance encountered cues and use them to solve the problem. This study also shows that cognitive-loading of the incubation task and problem difficulty are moderators of the cue-assimilation process.

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