Incubation and suppression processes in creative problem solving.

K J Gilhooly[1,2], G J Georgiou[1], M Sirota[1] & A. Paphiti-Galeano[1]

Department of Psychology, University of Hertfordshire[1]

Brunel Institute for Aging Studies, Brunel University London[2]

Address for correspondence: K.J. Gilhooly, Department of Psychology, School of Life and Medical Sciences, University of Hertfordshire, College Lane, Hatfield, Herts AL10 9AB, England, UK.

Email: k.j.gilhooly@herts.ac.uk

Research reported here was supported by Grant F00281G from the Leverhulme Trust to KJG and GG.

Abstract

The present study investigated the role of thought suppression in incubation, using a Delayed Incubation paradigm. A total of 301 participants were tested over five conditions, viz., Continuous Work Control, Incubation with a Mental Rotations interpolated task, Focussed Suppression, Unfocussed Suppression and a Conscious Expression condition. Checks were made for intermittent work during the Incubation condition. The target task was Alternative Uses for a brick. In the Incubation and suppression conditions, participants worked for 4 minutes then had a break during which Suppression or the interpolated task was carried out for 3 minutes before conscious work was resumed for a further 4 minutes on the Alternative Uses task. Results indicated that both Incubation with a distractor task and Suppression were effective in enhancing performance relative to Controls. The Intermittent work hypothesis was not upheld. The effects of Incubation/Suppression persisted over the post-incubation working period and the results suggested that Unfocussed Suppression effects on subsequent fluency lasted longer than Focussed Suppression effects.

Creative problems require the production of new approaches and solutions novel to the solver. Explaining how such novel solutions are reached is still a major challenge for the psychology of thinking. In analyses of creative problem solving it has often been claimed that setting creative problems aside for a period of time can lead to novel solution ideas occurring, either spontaneously while attending to other matters, or very rapidly when the previously intractable problem is revisited. Personal accounts by eminent creative thinkers in a range of domains have attested to this phenomenon (e.g., Ghiselin, 1952; Csikszentmihalyi, 1996). In a well known analysis of creative problem solving, Wallas (1926, p.80) labelled a stage in which the problem is set aside and not consciously addressed as “Incubation” and this stage of problem solving is the focus of the present study.

Following Wallas (1926), a substantial body of experimental research on incubation effects has accumulated using both (a) *insight* problems, in which there is a single solution, but the solver has to develop a new way of representing or structuring the task to reach solution and (b) *divergent* problems, in which there is no single correct solution but as many novel and useful ideas as possible are sought. In the classic laboratory paradigm for studying incubation effects, which we will label the *Delayed Incubation paradigm,* participants in the incubation condition work on the target problem for an experimenter determined time (preparation time) and are then given an *interpolated activity* away from the target task for a fixed time (incubation period) and finally return to the target problem for a post-incubation work period. Performance of the incubation group is contrasted with that of a control group who work continuously on the target task for a time equal to the sum of the preparation and post-incubation conscious working time of the incubation group. A recently developed variant (*Immediate Incubation paradigm*) employs an interpolated task for a fixed period *immediately* after instructions on the target problem and *before* any conscious work has been undertaken on the target problem, followed by uninterrupted work on the target problem (Djiksterhuis & Meurs, 2006). The present study focuses on the more widely studied Delayed Incubation paradigm.

There is now a substantial body of evidence from laboratory studies establishing the basic phenomenon of incubation, *viz*., that setting a problem aside is beneficial (see Dodds, Ward & Smith, 2003, for a qualitative review). A meta-analysis by Sio & Ormerod (2009), of 117 studies identified a positive effect of delayed incubation, where the overall average effect size was in the low-medium band (mean d = .32) over a range of insight and divergent tasks; for divergent tasks considered separately, the mean effect size (d) was larger at .65, which may be considered to be in the high-medium band of effect sizes. Although the basic existence of incubation effects can now be regarded as well established, clarifying the *mechanisms* underlying such effects remains a major challenge for cognitive research. The main hypotheses set out in the previous literature regarding the mechanisms underlying incubation effects can be summarised as follows.

1. *Intermittent Conscious work:* This suggests that although incubation is intended to be a period without conscious work on the target task nevertheless participants may carry out intermittent conscious work (Seifert, Meyer, Davidson, Patalano & Yaniv, 1995, p.82; Weisberg, 2006, pp. 443-445). This would provide a simple and unmysterious explanation of incubation effects as reflecting additional conscious work carried out by the incubation groups. Although this explanation has the virtue of parsimony, direct tests involving checks for intermittent work, found no support for it (Gilhooly, Georgiou, Garrison & Reston, 2012).

2. *Selective Forgetting:* This view (e.g., Simon, 1966) proposes an important role for automatic reduction in idea strength or activation. The proposal is that misleading strategies, mistaken assumptions and

related "mental sets" weaken through forgetting during the incubation period and thus a fresh start or "set shifting" is facilitated when the problem is resumed.

3. *Attention Withdrawal hypothesis:* On this account (Segal, 2004) the incubation break removes attention from a misleading assumption and on returning to the task there is a chance to "set shift" and adopt a more useful assumption.

4. *Unconscious work:* This approach proposes that incubation effects occur through active but unconscious processing of the problem materials (Poincaré, 1929; Campbell, 1960; Simonton 1995). Dijksterhuis and Nordgren (2006) report a number of studies in which better decisions and more creative solutions were found when the conditions of the decision and creative thinking tasks were such as to militate against conscious work. These studies did not follow the classical method of delayed incubation in which the problem is set aside *after* an extended period of conscious work. Rather, Dijksterhuis and Meurs (2006) had the participants *immediately* put aside the problem for a period after the task was presented, and *before* any conscious work could be carried out. In this *Immediate Incubation* paradigm, the mechanisms of beneficial forgetting, set switching and attentional withdrawal may be ruled out as there is no period of initial work in which misleading fixations and sets could be developed (of course, such processes could still be implicated in the classic Delayed Incubation paradigm). Dijksterhuis and Meurs (2006) have applied their *Unconscious Thought Theory* (UTT, Dijksterhuis & Nordgren, 2006) to Immediate Incubation. According to UTT, unconscious thought, compared to conscious thought, has a large capacity, proceeds relatively slowly, tends to be bottom up, is good at integrating many sources of information, is relatively poor at following rules and tends to divergent rather than convergent thinking. Dijksterhuis & Meurs took the beneficial effects of the Immediate Incubation paradigm as support for the role of unconscious work in incubation.

Further support for the unconscious work explanation was reported by Gilhooly, Georgiou and Devery (2013) in a study which varied the nature of the creative task (verbal or spatial) and the nature of the interpolated task (again, verbal or spatial) using a delayed incubation paradigm. An interaction was found between target task type and interpolated task type, such that a spatial interpolated incubation task benefitted a verbal creative task and a verbal interpolated incubation task benefitted a spatial creativity task. This pattern is consistent with an account in terms of resource competition. When conscious processes and unconscious processes draw on different resources (e.g., verbal vs. spatial) both can proceed with little mutual interference. However, if both draw on the same resources (e.g., both spatial) interference would be expected. Hence using non-overlapping resources in incubation and target task is beneficial compared to using overlapping resources. It may be noted that the study found no support for selective forgetting or attentional shifting explanations.

The present study concerns a novel direction for research which hypothesises a possible role for *thought suppression* processes in incubation. This approach is explained in the next section.

Suppression paradigm, Ironic Processes Theory and key results

A key aspect of incubation in real life is to set the main/target task aside for a period in which the problem solver decides *not* to think about the main task and instead decides to focus on other activities. In the laboratory paradigm, the solver is instructed to switch attention to a new task for a period and in order to achieve the desired focus on the interpolated task, solvers may *suppress* thoughts of the main task i.e., may effortfully and deliberately seek to avoid such thoughts and seek to terminate such thoughts if suppression fails. The process of *thought suppression* has been widely studied in social cognition, health and clinical psychology (see Wegner, 1994) but the possible role of suppression in incubation has not hitherto been examined. The main theory regarding thought suppression, the *Ironic Processes Theory* (Wegner, 1994; Wenzlaff & Wegner, 2000), implies that suppression keeps the to-be-avoided topic largely out of consciousness but in a state of high activation, which leads to a variety of unintended (ironic) effects. According to the Ironic Processes Theory, thought suppression involves two mechanisms: (a) an intentional operating process that seeks thoughts that will promote the desired state (anything other than the unwanted thought) and (b) an unconscious monitoring process that searches for mental contents that represent failures to suppress. The monitoring process has the ironic effect of maintaining the undesired content in a highly activated state and leads to unintended consequences such as intrusions of undesired thoughts during suppression and a strong resurgence or rebound of previously suppressed thoughts after a period of suppression.

Let us first outline two major and early established phenomena of suppression. In the classic suppression paradigm (Wegner, Schneider, Carter & White, 1987), one group first suppress a thought, e.g., of a white bear, for a fixed period and then express thoughts of a white bear in a subsequent expression period. A second group follow the reverse order, i.e., expression then suppression. From their extensive review of the suppression literature, Wenzlaff & Wegner (2000) reported the following key results from this paradigm:

1. Reporting of target thoughts is greater for Expression after Suppression, than for Expression without Suppression (*Post-suppression Rebound effect*).
2. Focussed distraction during Suppression (e.g., “Don’t think of a white bear, but if you do happen to, think of a red VW instead.”) reduces Rebound compared to unfocussed distraction (“Don’t think of white bear”). (*Focussed distraction effect*.)

Thought suppression mechanisms: beyond Ironic Processes.

In addition to Wegner's influential ironic process theory, other models have been developed to explain rebound effects, which may also be involved in incubation. One important feature of the incubation paradigm, especially in support of Unconscious Thought Theory has been the instruction to participants that they will return to the target task later on in the study, since unconscious processing is considered to be goal dependent (Bos, Dijksterhuis, & van Baaren (2008). There is growing evidence to suggest that rebound effects are also goal dependent. For example, the Intention Superiority Model (Erskine, 2004) highlights the instigation of the intention to suppress as a key component of rebound effects. Therefore if the intention (goal) to suppress is not formed then rebound effects are likely to be minimised. One possible explanation is that intentions and intention-related information are held at heightened levels of activation in memory (Goschke & Kuhl, 1993; Kuhl & Beckmannn, 1994), and this 'Intention Superiority Effect' could also be implicated in incubation effects. Other theoretical models to explain rebound effects such as Goal Nonattainment (Martin, Tesser, McIntosh, 1993; Martin and Tesser, 1996) are based on the Zeigarnik effect (1927), where unfulfilled goals are maintained in higher activation levels. Thought suppression tasks can be regarded as tasks that have unfulfilled goals, since the task is never completed because there are typically a number of thought intrusions during active suppression (Wenzlaff & Wegner, 2000). As incubation paradigms typically have incomplete tasks that participants return to after an interpolated activity, it is likely that intention and Zeigarnick effects may also potentially contribute to incubation effects. In addition, studies have recently shown that thoughts related to future tasks that would benefit from forethought lead to more thought intrusions compared to tasks that could not benefit from forethought, or when no future task was anticipated (Morsella, Ben-Zeev, Lanska, & Bargh, 2010). Other models such as the Motivational Inference Model (MIMO) explain rebound effects via motivational rather than cognitive processes (Förster and Liberman, 2001, 2004) and may also be relevant for incubation effects.

Thought suppression and activation

Studies in which suppression is of material irrelevant to the target task have suggested negative effects of suppression on subsequent problem solving. For example, the suppression of emotional reactions to video clips was shown to lead to a subsequent drop in anagram solution rates (Baumeister, Bratslavsky, Muraven, & Tice, 1998). A further study also demonstrated that after suppressing ‘white bear’ thoughts, participants quit sooner on an unsolvable anagram task, compared to control groups (expression and no thought manipulation) (Muraven, Tice & Baumeister, 1998). However, in these studies the thought suppression target was unrelated to the subsequent task and the poorer performance has been explained by the depletion of self-regulatory resources due to the effortful process of active suppression. In contrast, studies where the suppressed target was specifically related to the task have shown a ‘hyperaccessibility’ of the suppressed target during active suppression (Wegner & Erber, 1992) and after suppression has finished (Klein, 2007; Gordijn, Hindriks, Koomen, Dijksterhuis, & van Knippenberg, 2004). Conversely, Kozak, Sternglanz, Viswanathan, & Wegner, (2008) have shown that thought suppression can lead to a reduction in the generation (fluency) of creative associates when previously suppressing a semantically associated word. In the current study, the suppression target will be the same as the item of focus in the alternative uses task, and therefore it is predicted that suppression should lead to the concept of ‘brick’ being more highly activated following suppression which should facilitate fluency during the post-incubation alternative uses task.

Present study and predictions

We propose that, at least some participants, some of the time, in the standard incubation paradigms will engage in deliberate suppression of the target task during incubation, even though suppression is not usually explicitly part of the incubation instructions. Typically, participants are merely told at the start of the incubation period that for a while they will be set a different task, which they are to carry out as well as possible, during the incubation period, before a return to the main task; but, they are not explicitly told to suppress thoughts of the main task. Nevertheless, we suggest that some participants would spontaneously suppress thoughts of the previous task, since such thoughts would be likely to occur and would be distracting from the interpolated task. If, as we surmise, suppression is engaged in during the incubation period, then problem relevant information will be highly activated (even if kept below conscious level) during the incubation period and so may cause activation to spread in useful ways during incubation, which in turn could facilitate solutions when the task is resumed. Thus, a form of unconscious work, *viz.*, spreading activation, could be facilitated by deliberate suppression during incubation. The general hypothesis addressed here is that the effects of an incubation period are due, to some extent at least, to suppression processes that maintain problem relevant information in a highly active state.

In the studies reported below, we investigated suppression effects on incubation (a) with normal instructions which may induce suppression but do not explicitly instruct participants to suppress and (b) with explicit suppression instructions. We expect suppression-like effects in both conditions but with increased suppression-like effects with explicit suppression instructions.

The study reported here involved the Delayed Incubation paradigm using a divergent task (Unusual Uses for a Brick). In this task participants produce as many uses as they can that are different from the normal uses of a brick in a limited time. Such tasks have been found to be good test-beds for Incubation effects (Sio & Ormerod, 2009). The task involves use of remote associations to the target word (brick) and so should benefit from spreading activation from the target which can be expected to arise strongly as an ironic effect from suppression of “brick”. A further reason for using the divergent thinking task in the present study is that we have extensive experience of using this task (e.g., Gilhooly et al.,2007; Gilhooly et al., 2012, 2013).

EXPERIMENT

Participants

A total of 301 participants took part in the study. Participants were students at the University of Hertfordshire and were paid £10 per hour. Participants were 65% female and ages ranged from 18 to 49, with a mean age of 22.15 yrs and SD of 5.20 yrs.

Procedure

The target task was the divergent “Unusual uses of a brick” task. Instructions were as follows.

“In a moment, I will give you a task in which I want you to produce as many different uses as you can think of for a given object, that differ from its normal use. For example, the normal use for a newspaper is for reading, but it could also be used for swatting flies, to line drawers, to make a paper hat and so on. The object’s normal use will be stated but you are to try and produce as many possible uses which are different from the normal one and that are different from each other. The object is a ***brick*** *and it is typically used in building walls”.*

Immediately following instructions on the uses task, a Control group wrote down uses following instructions for 8 mins of continuous work.

A Normal Incubation group had 4 minutes writing down uses and were then given a spatial distraction task, viz., Mental Rotations (Peters et al., 1995), to carry out as accurately as they could for 3 mins. Mental Rotations had been found to reliably evoke incubation effects in our previous studies (Gilhooly et al., 2011; 2013).This group received normal incubation instructions to address the interpolated task without being explicitly instructed to suppress thoughts of the target task. After the 3 min incubation periods carrying out mental rotations, participants wrote down as many uses of a brick as they could for 4 mins.

A Conscious Work/Expression group had 4 minutes writing down uses, then 3 minutes consciously thinking about bricks, while thinking aloud, but not writing responses, and then had a further 4 mins to write down uses. The instructions for this group during the incubation period were as follows.

"Please could you try ***to think about a brick****. Please think aloud and* tell me everything you are thinking. *If you do think about a brick during this task, please* <u>*push a buzzer*</u>*, for each time this happens."*

A Suppression group was simply asked to suppress thoughts of the brick task for 3 mins during the incubation period, without an experimenter determined focus, again while thinking aloud. Instructions for this group were as follows.

> *"Please could you try* ***not to think about a brick****. Please think aloud and* tell me everything you are thinking. *If you do think about a brick during this task, please* <u>*push a buzzer*</u>*, for each time this happens."*

Finally, a Focussed Suppression group was given a specific topic to think aloud about (viz., a red Volkswagen) in the incubation period as well as suppression instruction. Instructions for this group were as follows.

"Please could you try ***not to think about a brick****. Please think aloud and* tell me everything you are thinking. *If you do think about a brick during this task, please* push a buzzer*, for each time this happens. Also, if you do happen to think of a brick, please try to think of a red Volkswagen instead."*

Following incubation periods all the experimental groups were asked to write down responses in 4 mins of resumed work on the uses task.

At the start of the incubation period the experimental groups were instructed that the task would be returned to after a gap. That is, the goal to resume the main task was explicit. An explicit resumption goal makes the situation closer to real life incubation situations and should maximise the likelihood of problem related unconscious activity during the incubation period, which has been found to be boosted by active relevant goals (Bos, Djiksterhuis & van Baaren, 2008; Zhong, Djiksterhuis & Galinsky, 2008). Also, giving explicit return instructions should lead to less unwanted individual variation due to some participants anticipating a return and some not doing so.

RESULTS

Performance was scored in terms of Fluency (number of distinct uses) over the 8 minutes of conscious work. The main results are shown in Table 1.

< INSERT TABLE 1 ABOUT HERE>

Overall, the groups differed on fluency, F (4,295)= 4.43, p <.005, part η^2 = .06. Post hoc tests indicated that suppression, focussed suppression, incubation and conscious work groups differed from the control group (p <.01) but not from each other.

As a check on the possibility of intermittent conscious work during the incubation period for the group who carried out mental rotations during incubation we compared scores on mental rotations between the experimental group and controls who did mental rotations as a stand alone task rather than as an incubation activity. Contrary to the intermittent work hypothesis, the experimental group performed better with an average of 7.01 (sd = 2.66) mental rotations attempted vs. 5.55 (sd = 2.38) by the controls (t (118) = 3.16, p < .01); the experimental group were also superior in number of correct mental rotations with an average of 4.98 (sd = 3.12) correct vs. 2.78 (sd = 2.10) by the controls (t(118) = 4.51, p < .001). As in previous studies, (Gilhooly et al., 2012) we have found no support for the intermittent conscious work hypothesis for incubation effects.

As a manipulation check on whether the suppression instructions reduced “brick” related thoughts, number of mentions of “brick” in the think aloud records for the suppression and expression or conscious work conditions were tabulated. See Table 2.

<INSERT TABLE 2 ABOUT HERE >

From Table 2 it can be seen that the suppression instructions did reduce the number of Brick thoughts reported during think aloud relative to the number reported by the conscious work/expression group. The overall differences between the groups were significant (F(2,177) = 51.47, p <.001, part η^2 = .37). Post hoc tests indicated that both suppression groups were significantly different from the conscious work group (p < .001) but were not significantly different from each other.

<INSERT FIG 1 ABOUT HERE>

From Figure 1 it can be seen that for the post-incubation fluency (i.e., fluency in the final 4 minutes of work), the control group scored lower than all the other groups, which were similar to each other. The overall difference between groups was significant, $F(4,295) = 6.14$, $p < .001$, part $\eta^2 = .08$, and post hoc tests revealed that all experimental groups were significantly different to the control group (all *p*'s < .01) but experimental groups were not different to each other

Scores were available for each minute of work from the first to the eighth minute. We assessed time course effects by examining the interaction of group with time periods. See Fig.2 below. Overall, there was a large and significant effect of time, F (7,1869)= 226.09, p <.001, part. $\eta^2 = .46$, such that fluency tends to fall over time. There was a significant interaction of group x time, $F(28,1869)$= 1.74, $p < .005$, part. $\eta^2 = .03$. The interaction reflects the "bounce" between minutes 4 and 5 in performance for the intervention groups when they resume the task in minute 5 after their incubation interpolated activities between minutes 4 and 5, as compared to the steady decline in the control group who have no change of activity between minutes 4 and 5.

<INSERT FIG. 2 ABOUT HERE >

Focussing on the post incubation responses and their time course, we assessed the effects of experimental condition for each minute, separately, following incubation. (For the continuous work control, we used scores from minutes 4-8) See Table 3.

<INSERT TABLE 3 ABOUT HERE>

Overall, it can be seen from Table 3, that the differences between the groups were significant at each minute time period post-incubation. Further, at minutes 5-7 in the post incubation period, post hoc tests showed the same pattern of results, viz., the continuous work control was significantly less productive than any of the experimental conditions ($p < .05$), but the experimental conditions were not significantly different from each other. In the final minute of post-incubation working, unfocussed suppression and normal incubation were more productive than controls ($p < .05$) but the previous advantages of focussed suppression and conscious work over controls were lost.

DISCUSSION

This study was designed to indicate whether deliberate suppression in incubation is beneficial, which would have implications for theory as well as practical applications in creative work. It does appear from our results that a period of incubation involving suppression regarding the main task, whether the suppression was focussed or not, was beneficial relative to continuous work. However, no major differences were found in the effectiveness of focussed *v.* unfocussed suppression; and both forms of suppression were found to be as effective as incubation involving a demanding externally focussed task (mental rotation) in terms of total productivity.

Carrying out conscious work on the task during the "incubation" period (without writing down answers) was beneficial, relative to the control , as we would expect, since that group was allowed an extra 3 minutes to work on the main task, only subject to the constraint that they could not write down their responses until the "incubation" period was complete. This group represent an extreme case of "intermittent working" in which work was as continuous as the participants wished. It is striking that incubation periods where attention was away from the main task, whether involving explicit suppression or a focus on a different task (normal incubation), resulted in similar gains in performance as an equivalent period of conscious work, relative to the control group. Overall, the post incubation benefits of suppression support the idea of a post suppression rebound with high activation of Brick and associated concepts leading to increased accessibility of task relevant information.

The temporal analysis presented here indicates that there is a spike in productivity immediately on resumption of the task after incubation and that the benefits of incubation periods persist over several minutes and do not dissipate very shortly after resumption. So, interpolated incubation activities had more than transient effects. It was notable that the effects of unfocussed suppression did last longer than the effects of focussed suppression, consistent with the hypothesis that unfocussed suppression would have stronger effects than focussed suppression, as has been found with reduced re-bound effects in suppression/expression studies for focussed suppression.

We have found here that different incubation conditions produce quite similar beneficial effects. How might these results fit the wider debate about processes underlying incubation? Previously we have argued (Gilhooly et al., 2012; 2013) in the context of the Uses task, that in normal incubation where attention is focussed on a demanding interpolated task, such as mental rotations, spreading activation occurs in parallel to the flow of conscious processing and that on task resumption more remotely associated information has been made available to inform the post incubation stage of conscious work. In the suppression conditions, the interpolated task is apparently less demanding, simply to think of anything, possibly daydreaming, subject only to the constraint of not thinking about the main task. On the basis of Wegner's (1994) influential analyses it is generally accepted that suppression causes high activation of the to-be-avoided concept. So, it is likely that "Brick" in our study was highly activated in the suppression conditions which led to spreading of activation to remotely associated information, which was then available post-incubation, thus boosting performance. The conscious work condition was similar in effectiveness to the other incubation conditions which were intended to preclude even intermittent work on the Uses task. It is perhaps surprising that the extra 3 minutes conscious work condition did not produce better results than the other incubation conditions in which unconscious work in the form of spreading activation is assumed. Two factors might reduce the effectiveness of the conscious work period. One is that participants would have to rely on memory to store any Uses they derived during the work period since use of "external memory" by writing down results was precluded. This would mean a loading of working memory and would limit the number of uses that could be pre-stored for reporting immediately after the task resumed. A second reason is that conscious work, using strategies such as scanning features of Brick as a cue for possible uses (Gilhooly et al., 2007), may be relatively slow compared to spreading activation.

Further studies might profitably address more subtle differences between focussed and unfocussed suppression as incubation activities. Possibly the benefits of unfocussed suppression persist well beyond those of focussed suppression, as our results suggest.

Finally, it may be noted, that from a practical point of view, our results suggest that engaging in thought suppression can be an effective form of incubation.

REFERENCES

Baird, B., Smallwood, J., Mrazek, M.D., Kam, J.W.Y, Franklin, M.S., & Schooler, J.W. (2012). Inspired by distraction: Mind wandering facilitates creative incubation. *Psychological Science,* **23**, 1117-1122.

Baumeister, R. F., Bratslavsky, E., Muraven, M., & Tice, D. M. (1998). Ego depletion: Is the active self a limited resource? *Journal of personality and social psychology, 74*, 1252-1265.

Bos, M. W., Dijksterhuis, A., & van Baaren, R. B. (2008). On the goal-dependency of unconscious thought. *Journal of Experimental Social Psychology, 44*, 1114-1120.

Campbell, D. T. (1960). Blind variation and selective retention in creative thought as in other knowledge processes. *Psychological Review, 67*, 380-400.

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention*. New York: HarperCollins.

Dijksterhuis, A., & Meurs, T. (2006). Where creativity resides: The generative power of unconscious thought. *Consciousness and Cognition, 15*, 135-146.

Dijksterhuis, A., & Nordgren, L. F. (2006). A theory of unconscious thought. *Perspectives on Psychological Science, 1*, 95-109.

Dodds, R. A., Ward, T. B., & Smith, S. M. (2003). A review of the experimental literature on incubation in problem solving and creativity. In M. A. Runco (Ed.), *Creativity research handbook* (Vol. 3). Cresskill, NJ: Hampton Press.

Ellwood, S., Pallier, P., Snyder, A., & Gallate, J. (2009). The incubation effect: hatching a solution? *Creativity Research Journal*, **21**, 6-14.

Erskine, J. A. K. (2004). *How Paradoxical are the Effects of Thought Suppression? The Nature of Mental Control and the Factors that Influence it*. Doctoral thesis, University of Hertfordshire.

Finke, R. (1990). Creative implications. In R. Finke (Ed) *Creative imagery: Discoveries and inventions in visualisation* (pp167-177). New Jersey: Lawrence Earlbaum Associates.

Finke, R.A., & Slayton, K. (1988). Explorations of creative visual synthesis in mental imagery. *Memory and Cognition*, 16, 252-257

Förster, J., & Liberman, N. (2001). The role of attribution of motivation in producing post-suppressional rebound. *Journal of Personality and Social Psychology, 81*, 377-390.

Förster, J., & Liberman, N. (2004). A motivational model of post-suppressional rebound. In W. Stroebe & M. Hewstone (Eds.), *European Review of Social Psychology,* (Vol 15, 1-32). Hove, UK: Psychology Press.

Ghiselin, B. (1952). *The creative process: A symposium*. New York: Mentor.

Gilhooly, K. J., & Hay, D. (1977). Rated characteristics of 205 five letter words having single solution anagrams. *Behaviour Research Methods & Instrumentation, 9*, 12-17.

Gilhooly, K. J., Fioratou, E., Anthony, S. H., & Wynn, V. (2007). Divergent thinking: Strategies and executive involvement in generating novel uses for familiar objects. *British Journal of Psychology*. **98**, 611-625.

Gilhooly, K. J., Georgiou, G. J., Garrison, J., Reston, J. D. & Sirota, M. (2012). Don't wait to incubate: Immediate versus delayed incubation in divergent thinking. *Memory and Cognition,* **40**, 966-975.

Gilhooly, K. J., Georgiou, G. J., & Devery, U. (2013). Incubation and creativity: Do something different. *Thinking and Reasoning,* **19**, 137-149.

Gordijn, E. H., Hindriks, I., Koomen, W., Dijksterhuis, A., & Van Knippenberg, A. (2004). Consequences of stereotype suppression and internal suppression motivation: A self-regulation approach. *Personality and Social Psychology Bulletin, 30,* 212-224.

Helie, S. & Sun, R. (2010). Incubation,insight, and creative problem solving: a unified theory and a connectionist model. *Psychological Review*, **117**, 994-1024.

Klein, A. A. (2007). Suppression-induced hyperaccessibility of thoughts in abstinent alcoholics: A preliminary investigation. *Behaviour research and therapy*, *45*, 169-177.

Kozak, M., Sternglanz, W. R., Viswanathan, U., & Wegner, D. M. (2008). The role of thought suppression in building mental blocks. *Consciousness and Cognition*, *17,* 1123-1130.

Kuhl, J., & Beckmannn, J. (1994). *Volition and personality: Action verses state orientation*. Göttingen, Germany: Hogrefe.

Martin, L., & Tesser, A. (1996). Some ruminative thoughts. In R. S. Wyer (Ed.), *Advances in social cognition*. (Vol. 9, pp. 1-48). Hillsdale, NJ: Lawrence Erlbaum Associates.

Martin, L. L., Tesser, A., & McIntosh, W. D. (1993). Wanting but not having: The effects of unattained goals on thoughts and feelings. In D. M. Wegner & J. W. Pennebaker (Eds.) *The handbook of mental control* (pp. 552-572). Englewood Cliffs, NJ: Prentice Hall.

Morsella, E., Ben-Zeev, A., Lanska, M., & Bargh, J. A. (2010). The spontaneous thoughts of the night: How future tasks breed intrusive cognitions. *Social cognition*, *28*, 641-650.

Muraven, M., Tice, D. M., & Baumeister, R. F. (1998). Self-control as a limited resource: Regulatory depletion patterns. *Journal of Personality and Social Psychology, 74*, 774-789

Peters, M., Laeng, B., Latham, K., Jackson, M., Zaiyouna, R., & Richardson, C. (1995). A redrawn Vandenberg and Kuse Mental Rotations Test: Different versions and factors that affect performance. *Brain & Cognition, 28,* 39-58.

Poincaré, H. (1929). *The foundations of science*. New York, NY: Science House.

Segal, E. (2004). Incubation in insight problem solving. *Creativity Research Journal, 16*, 141-148.

Seifert, C. M., Meyer, D. E., Davidson, N., Patalano, A. L., & Yaniv, I. (1995). Demystification of cognitive insight: Opportunistic assimilation and the prepared-mind perspective. In R. J. Sternberg and J. E. Davidson (Eds.), *The nature of insight*. Cambridge, MA: MIT Press.

Simon, H. A. (1966). Scientific discovery and the psychology of problem solving. In R. Colodny (Ed.), *Mind and cosmos*. Pittsburgh, PA: University of Pittsburgh Press.

Simonton, D. K. (1995). Foresight in insight? A Darwinian answer. In R. J. Sternberg and J. E. Davidson (Eds.), *The nature of insight*. Cambridge, MA: MIT Press.

Sio. U.N. & Ormerod, T.C. (2009). Does incubation enhance problem solving? A meta-analytic review. *Psychological Bulletin*, **135**, 94-120.

Smith, S. & Blankenship, S. (1991). Incubation and the persistence of fixation in problem solving. *American Journal of Psychology, 104,* 61-87.

Smith, S. & Vela, E. (1991). Incubated reminiscence effects. *Memory and Cognition*, **19**, 168-176.

Snyder, A., Mitchell, J., Ellwood, S., Yates, A., & Pallier, G. (2004). Nonconscious idea generation. *Psychological Reports,* **94**, 1325-1330.

Vandenberg, S.G. & Kuse, A.R. (1978). Mental Rotations: a group test of three-dimensional spatial visualization. *Perceptual and Motor Skills*, **47**, 599-604.

Wallas, G. (1926). *The art of thought*. New York: Harcourt Brace.

Wegner, D. M., & Erber, R. (1992). The hyperaccessibility of suppressed thoughts. *Journal of Personality and Social Psychology*, *63*, 903.

Weisberg, R.W. (2006). *Creativity: Understanding innovation in problem solving, science, invention, and the arts*. New York: J. Wiley & Sons.

Wenzlaff, R. M., & Wegner, D. M. (2000). Thought suppression. *Annual review of psychology, 51*, 59-91.

Zeigarnik, B. (1927). On the recall of completed and incompleted tasks. *Psychologische Forschung, 9*, 1–85.

Table 1. Average fluency scores over 8 minutes on Uses task

Group	N	Mean	SD
Suppression	66	16.53	6.73
Focussed Suppression	55	17.09	6.45
Incubation	62	16.14	6.23
Conscious Work	60	16.58	6.76
Control	58	12.83	5.59

Table 2. Number of "brick" thoughts during 3 min suppression incubation and expression periods

Group	N	Mean	Std. Deviation
Suppression	66	6.35	6.52
Conscious work	60	14.41	5.21
Focused suppression	55	5.05	4.10

Table 3. Effects of groups on average fluency at each minute after incubation.

Time after incubation	F (4,295)	p =	Part η^2
Minute 5	5.65	.001	.07
Minute 6	2.53	.04	.03
Minute 7	3.35	.01	.04
Minute 8	3.06	.02	.04

Figure 1. Mean post-incubation fluency scores by group. Bars indicate +/- 1 S.E. around the means.

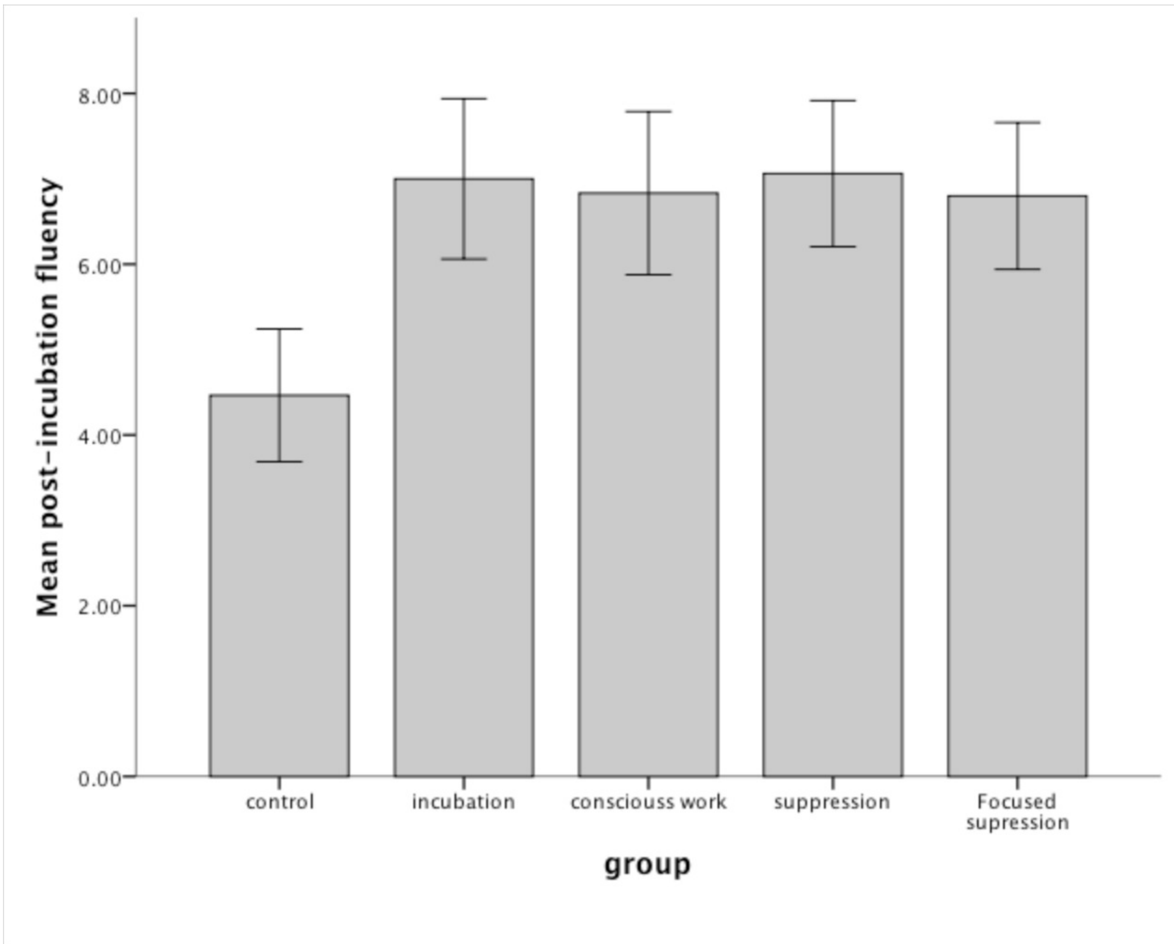

Figure 2 Mean fluency scores per minute of work for all groups. Minutes 1-4 are pre-incubation and minutes 5-8 are post-incubation for all groups except the control group who worked continuously from minute 1-8.