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Task unrelated thought whilst encoding information

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Abstract

Task unrelated thought (TUT) refers to thought directed away from the current situation, for example a daydream. Three experiments were conducted on healthy participants, with two broad aims. First, to contrast distributed and encapsulated views of cognition by comparing the encoding of categorical and random lists of words (Experiments One and Two). Second, to examine the consequences of experiencing TUT during study on the subsequent retrieval of information (Experiments One, Two, and Three). Experiments One and Two demonstrated lower levels of TUT and higher levels of word-fragment completion whilst encoding categorical relative to random stimuli, supporting the role of a distributed resource in the maintenance of TUT. In addition the results of all three experiments suggested that experiencing TUT during study had a measurable effect on subsequent retrieval. TUT was associated with increased frequency of false alarms at retrieval (Experiment One). In the subsequent experiments TUT was associated with no advantage to retrieval based on recollection, by manipulating instructions at encoding (Experiment Two), and/or at retrieval (Experiment Three). The implications of the results of all three experiments are discussed in terms of recent accounts of memory retrieval and conscious awareness.

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1. Introduction

When engaged on a task, one's attention can be directed to information not readily observable in the current environment, and instead we are engaged in the processing of internally generated information such as memories. The attentional shift that accompanies the processing of internally generated information may represent a situation in which the content of conscious awareness becomes, to some extent, decoupled from the processing of 'external' perceptual information (Kanwisher, 2001; Merikle, Smilek, & Eastwood, 2001). Kanwisher (2001) suggests that the stimulus features that are associated with the contents of awareness fall into one of the following three categories: (i) low level stimulus features such as stimulus detection, (ii) mid level features such as stimulus shape or (iii) the higher level meaning of the stimuli (Kanwisher, 2001). It is likely that these features are, at least to some extent, served by different neural systems, and the understanding of the interaction of these different codes of neural information may be important in our understanding of conscious awareness (see for example the consciousness as fame metaphor, Dennet, 2001).

This paper describes three experiments that investigated the consequences of processing internally generated information whilst ostensibly engaged in a task to encode verbal information. In these experiments a shift in attention was measured through the use of a thought probe which terminates the current block of the task, as has been described elsewhere (Smallwood, Obonsawin, Reid, & Heim, in press-A; Smallwood, Obonsawin, & Reid, in press-B). Using this paradigm, thoughts are recorded verbatim and classified in terms of whether they reflect attention to matters unrelated to the task in hand or the current situation task unrelated thought (TUT, see Smallwood et al., in press-B for detailed criteria on making these judgements).¹ One focus for this article is the contrast between encapsulated and distributed accounts of cognition, in terms of their predictions for the distribution of TUT. The second is the analysis of the empirical consequences of experiencing TUT on memory retrieval, particularly focusing on the contrast between the influences of recollection and familiarity on retrieval from memory (Jacoby, 1998; Jennings & Jacoby, 1993).

1.1. Encapsulated models

Maintaining ones attention on the current task has been historically ascribed to the resources directed to task completion (e.g., Giambra, 1995). For example, it has been suggested that TUT was the product of a limited all-purpose cognitive resource (Antrobus, 1968) and similar models have been suggested to explain the 'unitary' nature of consciousness (e.g., Mandler, 1975; Posner & Kline, 1973). Broadly, encapsulated models of processing propose that the amount of TUT experienced during any given task is inversely proportional to the amount of resources deployed

¹ TUT may be considered a naturally occurring situation in which attention is dissociated from awareness (Smallwood, Obonsawin, & Heim, 2003).

towards the task. In this context, ‘Effort’ may be conceptualised in terms of bits of information processed per second (Giambra, 1995).

Empirical research into TUT broadly supports the prediction of an encapsulated resource (Antrobus, 1968; Giambra, 1995). There is, for example, a robust and replicable influence of presentation rate of stimuli on TUT production during vigilance (e.g., Antrobus, 1968; Giambra, 1995). In addition, increasing the size of a digit string to be shadowed decreases the report of TUT whilst shadowing numerical information (Teasdale, Lloyd, Proctor, & Baddeley, 1993). Viewed from the perspective of an encapsulated system, qualitative differences in the contents of awareness stem from quantitative differences in the deployment of attentional and cognitive resources. These changes can be ascribed to changes in low-level stimulus features (Kanwisher, 2001).

1.2. *Distributed models*

The notion of schema arose in cognitive psychology out of a need to recognise that higher-level structures were necessary to describe the complex relations implicit within our knowledge base (Minsky, 1975). Schematic processing has been demonstrated to play an important role in a wide range of processes, such as memory (Brewer & Treyns, 1981), the maintenance of social norms via the use of scripts (Shanck & Abelson, 1977) and text comprehension (Westby, 1999). A schematic approach to cognition provides a mechanism whereby the global state of the system, *the context of information processing*, can facilitate the processing of local information.

Accounts of cognition which are consistent with the role of global states in information processing (such as schemata) are those models that can be considered ‘distributed’ (e.g., Faulconnier & Turner, 1998; Kennephol, 1999; Rumelhart & McClelland, 1986). A well-established example of a distributed account of cognition is parallel distributed processing (PDP, Rumelhart et al., 1986). The main features of a PDP network are generally agreed upon (Kennephol, 1999; Smolensky, 1999). Kennephol (1999) identifies three broad characteristics of PDP networks. In PDP networks: (i) information processing occurs in parallel, (ii) representations are not associated with a single entity, rather they are distributed across the network as a whole, and (iii) concepts are represented by activation patterns across the system as a whole therefore avoiding the necessity of a central executive (Kennephol, 1999).

One area where distributed models of cognition are particularly relevant is in the generation and maintenance of categories (see Pinker, 1997). The distributed approach to cognition is consistent with this prototypical view of category membership (see Barsalou, Huttenlocher, & Lamberts, 1998; Mandelblat & Zachar, 1998, pp. 243–247; Rumelhart et al., 1986, pp. 183–192; see also Wittgenstein, 1953) as both the prototypical view and the distributed approach share many assumptions regarding categorical perception. For example, both the connectionist view and the prototype view propose that category membership depends upon frequent experience of category members, a position supported by empirical evidence (Barsalou et al., 1998).

Recent evidence has examined whether contextual² features can affect the experience of TUT. One contextual feature of relevance is the goal state of the individual: their current concerns.³ Ecological evidence suggests that as individuals go about their day-to-day lives they are often pre-occupied with their current concerns (Klinger, Barta, & Maxeiner, 1980). Moreover, overlap between questionnaires measures of daydreaming and coping strategy, implies that daydreaming may function to re-enforce coping behaviours (Greenwald & Harder, 1995, 1997). Evidence from a laboratory situation is consistent with these findings (Klinger, 1978). Participants were engaged in a dichotic listening task with two streams of verbal information, one of which was relevant to the individual's current concerns, and one that was not. The results suggested that participants spent more time listening to the tape reflecting their current concerns and reported more thoughts relevant to those issues (Klinger, 1978). It seems plausible, therefore, that the experience of TUT may "serve as a continual reminder of the rest of the persons agenda" (Klinger, 1999, p. 439). In one important aspect, therefore, TUT is clearly affected by the internal context of the individual.

It has been suggested that TUT is a consequence of the individual's goals and motivation and is, therefore, likely to be associated with functional consequences, such as facilitating problem solving by the conceptual manipulation of semantic information (Baddeley, 1999; Binder et al., 1999). Binder and colleagues investigated the role conceptual semantic processing plays in the experience of TUT. During vigilance, TUT was reported less frequently than during an eyes-shut control condition. The results of a subsequent fMRI experiment suggested that a network of left-hemisphere poly-modal cortical regions, including the pre-frontal cortex, showed lower levels of activation during vigilance than either during the resting state or the semantic processing task (Binder et al., 1999). These findings suggest that similar "conceptual" activation is involved in the on-going, task unrelated, conscious activity during the resting state as is involved during the semantic processing task. Binder and colleagues suggest that such a capacity has a functional basis: "By storing and manipulating internal information [of a conceptual nature] we organise what could not be organised during stimulus presentation, solve problems that require computation over long periods of time, and create effective plans governing behaviour in the future. These capabilities have surely made no small contribution to human survival and the invention of technology" (Binder et al., 1999, p. 85).

Smallwood et al. (2003) attempted to clarify the role of conceptual processing by comparing the experience of TUT whilst processing information organised either alphabetically or in meaningful semantic categories. These experiments allowed a

² Contexts, in this sense "can be thought of as information that the nervous system has already adapted to; it is the ground against which new events are defined" (Baars, 1988). Contexts can be either internal, within the individual, or external, in the immediate environment, but as the above quote implies are best seen as an interaction between both. It is clear that whilst experiencing TUT can be seen as a situation in which the correspondence between the internal and external contexts are reduced.

³ Current concerns reflect the "hypothetical process active during the time that one has a goal" (Klinger, 1999, p. 439).

contrast between the predictions of a distributed resource with an encapsulated model of cognition in terms of their predictions regarding the frequency of TUT. In an encapsulated model, categorical processing is considered less effortful than non-categorical processing because categories/schemata represent a quality of information which are “highly organized, having a clear thematic structure” (Ellis & Ashbrook, 1986, p. 31). Based on an encapsulated view of the mind, therefore, categorical processing should yield higher frequencies of TUT. In contrast, a distributed model emphasises the context of information processing in mediating task focus. In the case of processing information organised into categories, the likelihood that the internal context of information processing corresponds to the external environment would be higher, making the experience of TUT less likely (Smallwood et al., 2003).

During both fluency and memory tasks, participants performed at a superior level and reported a lower frequency of TUT in the categorical tasks (Smallwood et al., 2003). This pattern of results is consistent with the role of a distributed resource in the generation of TUT. A possible problem with the experiments, however, was that the stimulus set used in each condition, categorical or alphabetical, was different prohibiting robust conclusions being drawn on the role of stimulus organisation (Smallwood et al., 2003).

The first aim of this paper was, therefore, to replicate and extend our knowledge of the relationship between categorical processing and TUT. In particular, this paper examined whether the categorical suppression of TUT was observed (i) when differences in the stimuli set are controlled for (Experiment One) and (ii) to examine the extent to which the suppression of TUT is concerned with processing the stimulus set per se, or is better understood as an affordance⁴ between task and stimulus materials (Experiment Two).

1.3. Task unrelated thought and encoding accuracy

If TUT reflects a shift in conscious awareness towards the processing of an internal source of information at the expense of exogenous attention, one would expect that this shift in information processing would co-occur with a change in external information processing. Moreover, given that the dependent measure in this series of experiments is subjectively reported information, and that the base rate for occurrence of these phenomena whilst encoding information is low (Smallwood et al., 2003, in press-B; Teasdale et al., 1993) it is clearly important to validate the subjective information reported by the individuals during task completion by reference to measurable aspects of task processing (Baars, 1988).⁵ Recently evidence has demonstrated subtle, measurable detriments in task performance that accompany the experience of TUT (Teasdale et al., 1995, Study Four; Smallwood et al., in

⁴ Micheals and Carello (1981) suggest that two important aspect of affordances are that they are (i) for acting on (p. 47) and (ii) they reflect constraints upon learning (p. 56).

⁵ Such validity concerns can generally be overcome by a comparison with an ‘objective’ criterion, this is often not attempted in research into TUT, as performance on the chosen tasks are often at ceiling (Giambra, 1995; Teasdale et al., 1993).

press-B). For example, Teasdale et al. (1995) suggested that the experience of TUT during a random number generation task was reflected in a decrease in the random nature of the numbers generated. More recently in the context of memory tasks, a positive correlation was observed between the report of TUT and the report of false alarms during recall (Smallwood et al., in press-B).

As TUT has been shown to be positively associated with higher levels of false alarms at the point of recall, it seems plausible that TUT during study may effect the encoding of information. It is generally accepted in the literature that retrieval can occur through two distinct routes. These two routes are described as recollection vs. familiarity (Jacoby, 1998; Jennings & Jacoby, 1993) or explicit vs. implicit (Szymanski & MacCleod, 1996). Broadly, the influences of recollection/explicit recall can be understood as the “conscious retrieval of an event” (Szymanski & MacCleod, 1996, p. 165) whilst familiarity/implicit influences occur “when a previously encountered stimulus affects behaviour without conscious knowledge” (Szymanski & MacCleod, 1996, p. 165).⁶ One important influence on recollection/familiarity is the nature of attention to the stimulus at the point of study. Both divided attention (Jacoby, 1998; Jennings & Jacoby, 1993; Parkin, Reid, & Russo, 1990) and directing attention to superficial stimulus features (Szymanski & MacCleod, 1996) seem to impair stimulus recollection, whilst leaving the effects of stimulus familiarity unaffected.⁷ As TUT reflects the explicit description by the participant that the contents of their attention departed from the current situation, it seems plausible that experiencing TUT during study may effect one or other component of subsequent retrieval: recollection or stimulus familiarity.

The second broad aim of these experiments is, therefore, to examine the consequences of experiencing TUT during study on the subsequent retrieval of information. In Experiment One we compared those individuals who report one or more TUT during study with those individuals who reported none, in an attempt to replicate the positive association between false alarms and TUT reported elsewhere (Smallwood et al., in press-A). Experiments Two and Three examine whether the effects of TUT on study of the subsequent retrieval of information can be understood in terms of the recollection/familiarity distinction. This was achieved by manipulating instructions at encoding (Experiment Two) and by manipulating instructions at retrieval (Experiment Three) using the process dissociation procedures developed by Jacoby and colleagues (Jacoby, 1998; Jacoby, Toth, & Yonelinas, 1993).

2. Experiment One

The aims of Experiment One are as follows. First to demonstrate that the categorical suppression of TUT reported in Smallwood et al. (2003) was not an artefact of the stimuli set used. We examined the frequency of TUT during the encoding of two sets of stimuli as a within-participant factor: one set of stimuli was presented in

⁶ For the sake of clarity we shall use the terms recollection and familiarity to refer to these phenomenon.

⁷ Similar perceptual phenomena occur in the work of Mack and Rock (1998).

blocks organised categorically, the other set organised in a random fashion. In line with previous research, it was expected that TUT will be lower during the categorical condition (Binder et al., 1999; Smallwood et al., 2003).

A second aim of this paper was to demonstrate replicable differences between those individuals whose attention is not maintained upon the task in hand in terms of accuracy of memory retrieval and the experience of task completion. It was predicted that individuals whose attention is not focused upon the task in hand will report a higher number of false alarms during recall (Smallwood, Obonsawin, Heim, & Reid, in press-A).

2.1. Method

2.1.1. Participants

Thirty participants were recruited from the Department of Psychology. All participants took part in a semi-structured interview in which they indicated in the affirmative if they at present, or at any point in the past, had suffered from any psychiatric neurological or substance based disorder. Two participants were excluded on the basis of a previous history of depression. Of the remaining 28 participants, 10 were male (approximately 36%), and 18 were female (approximately 64%). The mean age of the sample was 26.5 years ($SD = 9.9$). Each participant was paid £5 at the end of the experimental session.

2.1.2. Materials

Word-lists. The word-lists used in this and the subsequent experiment were devised from Battig and Montague's (1969) category norms. From these norms, sixteen categories (ranging from boys' names to alcoholic beverages) were selected. From each category, the most frequently reported 20 items were chosen and eight of these items were selected to use as unstudied items during the retrieval phase. These unstudied items reflected the frequency ranks 1, 4, 6, 9, 11, 14, 16, and 19. The remaining items yielded 16 categories of 12 items, which were divided into two sets of eight categories (set A and set B) matched for overall frequency and used for presentation during the study phase of this experiment. These two sets of words were then randomised, such that half the participants either received set A as blocks of random words and set B as blocks of categorical words. The other half of the participants received set A in categorical blocks and set B in random blocks. The presentation of words was counterbalanced to ensure that (i) each participant received words of similar frequency in both random and categorical blocks and (ii) that over the course of the experiment as a whole each condition contained the same words. The words were presented on screen for an average of 3.5 s. One second separated all words.

2.1.3. Measures

Thought probes. Before beginning, each participant was informed that:

When you see the word STOP I would like you to stop what you are doing and tell me exactly what was passing through your mind as you saw the word "STOP." I do not want you

to tell me what you were thinking about during the trial, just what was passing through your mind when you saw the word “STOP.”

Thought classification. Thoughts were recorded verbatim and later classified by the examiner and by two judges blind to the hypothesis of the experiment. Throughout the three experiments, thoughts were classified into one of three types of thoughts. Task related thoughts (TRTs) were defined as thoughts fully in the ‘here and now’ and therefore related to the task in hand. An example of TRT was “I was trying to remember the words.” Task related interference (TRI) reflected an appraisal of the task or one’s performance on the task. An example of TRI was “I don’t think I will be able to remember all of those words.” Finally, task unrelated thought (TUT) reflected thoughts with no relationship to the task in hand, or the current situation. An example of TUT was “Thinking about what I am going to have for dinner” or “I was thinking about a meeting I had yesterday.”⁸ The dependent measure was the frequency of each thought. The total number of recorded thoughts per condition was eight, and therefore 16 thoughts per individual were recorded for analysis. Three independent judges coded the verbal reports. The total number of thoughts for which the raters agreed was divided by the total number of thoughts (Smallwood et al., 2003, in press-B) and was at 91% for TUT, 88% for TRI, and 92% for TRT. When disagreement occurred, the disagreement was noted and further discussion was sought until it was resolved.

2.1.4. *Use of imagery*

Teasdale et al. (1993) demonstrated that TUT often took the form of sustained images. We utilised the same technique to allow the individuals to characterise their cognitive experience as either words, images or a combination of both. In addition to the measure of thought content, therefore, participants were asked, “During the block was your thinking characterised by words or images or both?” This question was asked twice in each condition, eight times in total. The type of experience probe always followed the thought probe.

2.1.5. *Memory retrieval*

Memory retrieval was measured at the end of each block and was measured using both word-fragment completion and word recognition. In the word recognition condition all 12 items plus the eight unstudied items from each word list were displayed on a sheet of paper in a random order. Participants were required to indicate items that had appeared during the previous trial. For the word-fragment completion condition, word-fragments were presented in which 25% of the letters for each word was shown. The location of the deleted letters was randomised. Participants were required to complete the words to create those that had appeared during the previous trial. Twelve word-fragments could be completed with items shown during study, eight could only be completed using new items. The type of retrieval was a

⁸ See Smallwood et al. (in press-B) for detailed criteria in making these judgements.

within-participants factor and the appropriate counterbalancing ensured that each participant completed four blocks of each type of retrieval for each condition. Both correct responses and false alarms were calculated.

2.1.6. Procedure

For half the participants the demographic measures were obtained first, the remainder completing them at the end of the experiment. This was decided prior to participation in the experiment and was carried out in a quasi-random basis.

Study phase. Before beginning the study phase of the experiment all participants were instructed that some words would appear one at a time on the computer screen, followed by the word ‘STOP.’ Their task was to read each word aloud and attempt to remember as many as possible. Stimulus organisation (categorical vs. random) was a within-participant condition. The order of presentation was alternated and each condition was counterbalanced across participants, to control for order effects.

Retrieval phase. The retrieval phase followed the measure of thought content/type of experience. Participants had a maximum of two minutes to complete retrieval before the next study block began. Retrieval alternated between word-recognition and word-fragment completion. As with block order, retrieval conditions were counterbalanced, to control for order effects.

2.1.7. Statistical analysis

Bearing in mind the low base rate for the overall frequency of TUT (less than 10%) the effects of stimulus organisation on thinking were compared using paired Wilcoxon tests in line with previous experiments (Smallwood et al., 2003, in press-B). To examine the effects of TUT during study on the subsequent retrieval of information from memory, in all three experiments presented in this paper, we classified individuals on the basis of whether their verbal reports of thinking contained one or more examples of TUT (TUT group) or their verbal reports of their thinking did not contain any examples of TUT (No TUT group). These groups were used in the subsequent analysis as between participant factors to compare the effects of the report of TUT on retrieval and on the type of cognitive experience during the block. These group differences were compared using ANOVA and Mann–Whitney *U* tests, respectively.

2.2. Results

2.2.1. Effects of conditions on task unrelated thinking

Table 1 contains the mean likelihood of each individual reporting each of the three categories of thought (TRT, TRI, and TUT) whilst studying either categorical or random information. A main effect of stimulus organisation was observed ($Z = -2.13, p < .05$), indicating that significantly fewer TUTs were reported during the categorical condition than in the random condition. No effect of stimulus organisation was observed for the experience of TRI ($Z = -1.19, p > .05$). Finally, a marginally significant effect of stimulus organisation on TRT was observed ($Z = -1.8, p = .06$).

Table 1

Experiment One: Mean frequency of TUT and mean correct responses and false alarms in categorical and random stimulus organisations for each individual (standard deviations in parentheses)

	Categorical		Random	
TUT	.18 (.39)		.50 (.75)*	
TRI	.73 (1.08)		1.03 (1.24)	
TRT	5.0 (1.28)		4.5 (1.30)*	
	Correct	False alarms	Correct	False alarms
Word fragments	8.4 (1.6)**	.2 (.2)	6.4 (1.9)	.3 (.3)
Word recognition	10.2 (1.1)	.4 (.5)	10.1 (1.2)	.2 (.3)

Note. TUT, task-unrelated thought; TRI, task-related interference; TRT, task-related thought. Maximum frequency of each type of thought is 8.

* Significant effect of stimulus organisation ($p < .05$, Wilcoxon).

** Significant effects of stimulus organisation ($p < .01$, ANOVA).

2.2.2. Demographic details

The sample was divided into two groups on the basis of the frequency of TUT. One group reported no TUT (No TUT group, $n = 16$) whilst the second reported between 1 and 3 TUT (TUT group, $n = 12$). Group differences in demography were examined. Of the No TUT group 11 were female and 5 were male. The mean age of the No TUT group was 26.36 ($SD = 9.4$). For the TUT group 7 were female and 5 were male. The mean age of the TUT group was 26.0 ($SD = 10.7$). Neither age, gender or length of full time education distinguished the two groups ($p > .05$).

2.2.3. Memory retrieval

Table 1 summarises the mean likelihood of a correct responses and false alarms reported during each retrieval phase for both stimulus organisations. Separate analysis was conducted to examine the effects of TUT on each retrieval condition (word-fragment completion vs. word recognition).⁹ Two separate ANOVAs were used to examine the influences on retrieval during task performance for each condition (word-fragment completion and word recognition). In both ANOVAs a within-participant factor (stimulus organisation) and a between-participants factor (TUT group) were included. No significant main effects or interactions were observed in the word-recognition condition. A main effect of stimulus organisation was observed for word-fragment completion ($F(1, 27) = 53.2$, $p < .001$) indicating superior word-fragment completion in the categorical condition. In addition, a main

⁹ Correlations were used to examine the hypothesis that experiencing task-related thinking (TRT and TRI) had effects on the retrieval of information. No significant correlations were observed between the frequency of TRT or TRI and the subsequent retrieval in terms of either correctly recalled items or false alarms (for all comparisons $p > .05$). This is in line with previous findings (Smallwood et al., in press-A).

effect of group was observed for false alarms during word-fragment completion ($F(1, 27) = 13.38, p < .001$). The distribution of false alarms was as follows: No TUT Group Mean False Alarms = .15 ($SD = .17$), TUT Group Mean False Alarms = .35 ($SD = .37$). The analysis indicated that significantly more false alarms were reported by the TUT group.

2.2.4. Experience during task completion

Thinking during task completion. In addition to differences in the frequency of TUT, we compared the distribution of the other two types of thinking (TRT and TRI) across each group. Thinking across the two groups was distributed as follows. TUT group: TRI Categorical 1.07 (1.2), TRT Categorical 4.46 (1.33), TRI Random .78 (.72), and TRT Random 4.2 (.90). No TUT group: TRI Categorical .47 (.88), TRT Categorical 5.54 (1.12), TRI Random 1.23 (1.52), and TRT Random 4.7 (1.53). Wilcoxon tests indicated that only the frequency of TRT reported in the categorical condition varied across groups ($Z = -2.4, p < .05$).

Type of experience. Fig. 1 describes the distribution of each type of experience reported. To examine the type of experience that participants reported during the task, separate planned comparisons were made to investigate the role of stimulus organisation and TUT group on the type of experience reported during task completion. Results indicated that the TUT group reported more reports of words only ($Z = -2.78, p < .01$) and fewer reports of both words and images ($Z = -2.2, p < .05$) than the No TUT group in the random condition only. Furthermore, over the sample as a whole, a greater number of images ($Z = 3.2, p < .001$) and reports of both images and words ($Z = -2.8, p < .01$) were reported in the categorical condition than in the random condition.

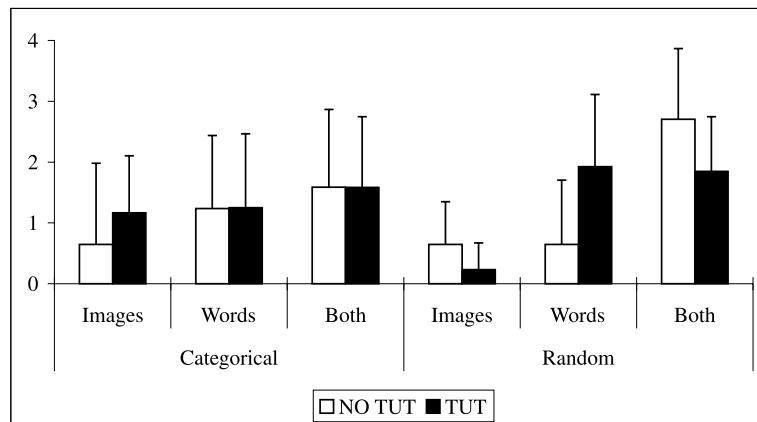


Fig. 1. Experiment One: Type of experience (image, words or both) by Task Unrelated Thought Group for a categorical and a random stimulus organisation. The Y-axis describes the mean likelihood of reporting that type of cognitive experience during the relevant condition.

2.3. Discussion

The results of Experiment One indicate that encoding a categorical stimulus organisation afforded enhanced word-fragment completion, fewer examples of TUT, and a larger number of TRT than did the random stimulus organisation. This replicates the findings of Smallwood et al. (2003) using a design that precludes the interpretation at the stimulus level alone.

As well as investigating the role of stimulus organisation in maintaining task focus, we set out to investigate the consequence of directing attention away from the task in hand upon memory retrieval. Previous research has indicated that any relationship between task performance and TUT is likely to be subtle (Teasdale et al., 1995). In the context of a memory task TUT has been shown to be proportional to the number of false alarms reported in free recall (Smallwood et al., in press-A). Experiment One demonstrated that the participants who reported at least one thought directed away from the task in hand reported significantly more false alarms during word-fragment completion than did those individuals who only reported thoughts that were directed towards the task (either TRT or TRI). The increase in false alarms suggests that participants who reported at least one TUT were impaired in their ability to accurately retrieve information presented during the study phase of the experiment. This validates our measure of TUT as it corresponds to a meaningful behavioural index in a reliable fashion (Smallwood et al., in press-A).

An unexpected result of this experiment was the effect of stimulus organisation upon the type of experience reported during task completion. In the categorical stimulus organisation, each of the three types of experiences were equally distributed (see Fig. 1). In contrast, during the random stimulus organisation participants were more likely to report an experience characterised by both words and images than either words or images alone. This difference was larger in those individuals who reported one or more TUTs.

3. Experiment Two

Several issues remain unclear regarding the findings of Experiment One. First, a consistent picture is developing that TUT is inhibited when processing a categorical stimulus organisation (Smallwood et al., 2003). These demonstrations use demanding tasks (either fluency or memory tasks) and task process has been acknowledged to be an important component of maintaining task focus (Teasdale et al., 1993). On the basis of the results of Experiment One alone it is unclear whether the decrease in TUT, during the processing of categorical material depends upon the stimulus organisation per se, or rather should be conceptualised as an affordance that a categorical stimulus organisation offers the individual who is instructed to encode the information. A further experiment was therefore conducted to compare a random and categorical stimulus organisation in which participants are asked to either (i) simply repeat the word (shadow condition) or (ii) to repeat the word and encode it for subsequent retrieval (study condition). If experiencing TUT depends upon the categorical stimulus organisation alone then superior task focus should be demonstrated regardless of

instruction. If task focus, on the other hand, is a consequence of the combination of the categorical stimulus organisation and the instruction to encode information then fewer TUTs will only be reported in the categorical study condition.

The second aim of Experiment Two concerns the effects of TUT during study on subsequent memory retrieval. The results of Experiment One replicate the finding that high levels of TUT are associated with high levels of false alarms (Smallwood et al., in press-A). As noted in the Introduction, memory retrieval is often considered to consist of a combination of two influences: recollection and familiarity (e.g., Jacoby, 1998). Moreover, previous work suggests that the experimental division of attention impairs the individual's ability to recollect the relevant information, whilst leaving the influence of familiarity relatively unaffected (Jacoby, 1998; Parkin et al., 1990; Szymanski & MacCleod, 1996). It seems plausible, therefore, that experiencing TUT during study may interfere with the individual's ability to retrieve information on the basis of recollection.

The design of Experiment Two allows us to examine this issue. In Experiment Two, participants were instructed that information from the blocks preceded by the instruction to shadow information was not to be encoded. Therefore, any information from the shadowing condition that is retrieved at the end of the task is likely to be a consequence of stimulus familiarity. On the other hand, information that was correctly retrieved from the study condition is likely to reflect the influences of a combination of automatic and conscious effects upon recall.

3.1. Method

3.1.1. Participants

Thirty-two participants were recruited from the Department of Psychology. As in Experiment One, participants were screened for past and current psychiatric conditions. Four participants were excluded on the basis of a previous history of depression. Of the remaining 28 participants, 13 were male (approximately 46%) and 15 were female (approximately 54%). The mean age of the sample was 30.5 years ($SD = 16.4$). Each participant was paid £5 at the end of the experimental session.

3.1.2. Procedure

Demographic information was obtained in the same manner as Experiment One. The stimuli set was identical to that used in Experiment One. During the retrieval condition at the end of the experiment, half of the words came from the encoding condition and the remainder from the shadowing condition. Unlike Experiment One, no unstudied words were presented.

Study phase. During study blocks, participants were instructed that their task was to read each word aloud and attempt to remember as many words as possible. During the shadowing blocks, participants were instructed to repeat each word after it disappeared from the screen. At the outset of each shadowing block participants were explicitly instructed not to encode the words for subsequent retrieval. Categorical and random organisation was alternated and the instructions (shadowing vs. study) varied such that there were four trials in each of the four conditions. The order of presentation was counterbalanced across participants.

Both measures of thought content (Thought Probe and Type of Experience) were administered in an identical fashion to Experiment One.

Retrieval phase. Unlike Experiment One, retrieval was measured at the end of the experimental session, rather than on a trial-by-trial basis. As before retrieval was measured using both word-fragment completion and word-recognition using a paper and pencil test. Before beginning the retrieval phase of the experiment, participants were reminded only to retrieve information from the ‘study’ blocks. Participants had a maximum of 10 min to complete the retrieval phase of the experiment.

3.1.3. *Measures*

Thought probes were administered and classified as described in Experiment One. Inter-rater agreement for TUT was at 90%, TRI was at 87%, and TRT was at 94%.

3.2. *Results*

3.2.1. *Effects of conditions on TUT*

Table 2 describes the distribution of thoughts across the four conditions of Experiment Two. To examine the effects of stimulus organisation and task on the distribution of thoughts, paired Wilcoxon tests were calculated on the overall mean scores for each level of thought. No main effect of either stimulus organisation (category or random) or instruction (study or shadow) was observed for TUT. An interaction between stimulus organisation and instruction was examined by subtracting the number of TUTs reported during the encoding conditions from the

Table 2
Experiment Two: Mean frequency of an individual reporting each type of thought (standard deviations) in each of the four conditions of Experiment Two

	Categorical		Random	
	Encoding	Shadowing	Encoding	Shadowing
<i>Overall sample</i>				
TUT	.09 (.29)*	.37 (.55)	.29 (.52)	.22 (.42)
TRI	.25 (.51)	.50 (.71)	.31 (.53)	.28 (.58)
TRT	2.6 (.60)*	2.12 (.79)*	2.4 (.71)*	2.5 (.67)*
<i>TUT group</i>				
TUT	.22 (.43)	.86 (.54)	.65 (.63)	.50 (.52)
TRI	.35 (.43)	.43 (.64)	.28 (.47)	.29 (.61)
TRT	2.42 (.65)	1.7 (.61)	2.1 (.73)	2.21 (.70)
<i>No TUT group</i>				
TUT	N/A	N/A	N/A	N/A
TRI	.17 (.51)	.56 (.78)	.33 (.60)	.28 (.57)
TRT	2.83 (.51)	2.44 (.78)	2.66 (.60)	2.72 (.57)

Note. Maximum frequency for each type of thought is 4.

N/A reflects the fact that No TUT group was selected on the basis of reporting no examples of TUT.

* Significant effect of stimulus organisation ($p < .05$, Wilcoxon).

shadowing conditions for each stimulus organisation. Comparing this index across stimulus organisation conditions yielded a reliable effect ($Z = -2.18, p < .05$). This interaction indicated that a categorical stimulus organisation benefited from the instruction to study the words whilst a random stimulus did not (see Table 2). This analysis was followed-up by examining the role of stimulus organisation separately in (i) the study and (ii) the shadowing conditions. A significant role of stimulus organisation was observed for the study ($Z = 2.11, p < .05$) but not for the shadowing condition ($Z = -1.41, n.s.$). These results indicate that the role of stimulus organisation in determining TUT is moderated by the instructions. A categorical stimulus organisation only led to a detectable change in TUT following the instruction to encode information.

No effect of either instruction (study vs. shadow), stimulus organisation (category vs. random) or any interaction was observed for TRI [for all comparisons $p > .05$]. No main effects were observed for the experience of TRT, although the effect of instruction approached significance ($Z = -1.72, p = .08$). However, the interaction between stimulus organisation and instruction was reliable ($Z = -2.7, p < .01$). To follow up this interaction we compared the effect of stimulus organisation on the distribution of TRT, separately across both instruction conditions. TRT was significantly higher following the instruction to encode in the categorical condition ($Z = -2.1, p < .05$) and lower following the instruction to shadow information ($Z = -2.0, p < .05$) in the same stimulus organisation (see Table 3).

3.2.2. Demographic details

As in Experiment One the sample was divided into two groups on the basis of the frequency of TUT. Of the TUT (TUT group, $n = 13$) group five participants were female, whilst eight were male. The mean age of the No TUT group was 30.7 years ($SD = 18.1$). In the No TUT group (No TUT group, $n = 15$), 10 participants were female, and five were male. The mean age of the No TUT group was 30.1 years ($SD = 15$). Neither age nor gender differed between the two groups ($p > .05$).

3.2.3. Memory retrieval

Two separate 2×2 ANOVA (instructions at study \times TUT group) were conducted on the likelihood of retrieving a word in either the word-fragment or the word-recognition conditions. In the word-recognition condition a main effect of instruction was observed [$F(1, 23) = 6.176, p < .05$]¹⁰ indicating that overall more words were correctly retrieved from the study blocks than incorrectly retrieved from the shadowing blocks. No effect of TUT group or the possible interaction was observed for the word-recognition condition. In the word-fragment condition, a main effect of instruction approached significance [$F(1, 23) = 3.485, p = .08$]. In addition, an Instruction \times TUT group interaction reached significance [$F(1, 23) = 4.30, p < .05$, see Fig. 3A]. Separate Univariate ANOVAs on each group indicated that a main effect of instruction was observed in the No TUT group [$F(1, 12) = 9.4, p < .01$] but not in

¹⁰ The degrees of freedom are different in the analysis of task performance because three individuals failed to comply with the instructions during the retrieval phase of Experiment Two and were subsequently excluded.

the TUT group ($p > .05$). This indicates that the No TUT group correctly retrieved a higher proportion of words from the study condition than from the shadow condition. Retrieval in the TUT group was equally distributed between the memory and the shadowing condition.¹¹

3.2.4. Experience during task completion

Thinking during task completion. As in Experiment One, we compared the distribution of the other two types of thinking across each group (see Table 2). Wilcoxon tests indicated that only TRT reported in the categorical condition varied across groups ($Z = -2.4, p < .05$).

Type of experience. To examine the type of experience reported by the participants during task performance, separate non-parametric planned comparisons were used to examine the role of stimulus organisation and process. Participants reported more imagery ($Z = -3.2, p < .001$) and fewer reports of both imagery and words ($Z = -2.5, p < .01$) in the categorical condition than in the random condition. The distribution of reported experience is displayed in Fig. 2. No effect of TUT group was observed in Experiment Two, although the differences were in the predicted direction [mean likelihood of reporting both images and words in the random encoding condition: No TUT = 1.28 ($SD = .83$), TUT group = 1.14 ($SD = .77$)].

3.3. Discussion of Experiment Two

The distribution of TUT reported in Experiment Two was consistent with the claim that stimulus organisation can moderate the report of TUT only when the participant was instructed to encode the information. A lower frequency of TUT was reported in the categorical condition following the instruction to encode relative to both the random memory condition and the categorical shadow condition. Furthermore, no effect of stimulus organisation was observed for the shadowing task for any type of thought.

Second, the distribution of information retrieved indicated that participants who reported one or more examples of TUT were as likely to retrieve information that they were instructed to encode as they were to retrieve information that was shadowed. In contrast, participants who reported no TUT were more likely to retrieve information that was studied for subsequent retrieval rather than shadowed. This supports the notion that similar to experimental divisions of attention (e.g., Jacoby, 1998) experiencing TUT yields consequences on subsequent retrieval that can be understood in terms of the recollection/familiarity distinction.

Finally, Experiment Two replicated the effects of stimulus organisation upon the report of the type of experience. In both Experiments One and Two, participants reported experiencing significantly more images and significantly fewer experiences of both words and images in the categorical condition. Unlike Experiment One, no effects of TUT group were observed in the type of experience reported.

¹¹ As in Experiment One, neither the frequency of TRI nor TRT reported in any condition of the experiment was associated with the number of items retrieved from memory [for all comparisons, $p > .05$].

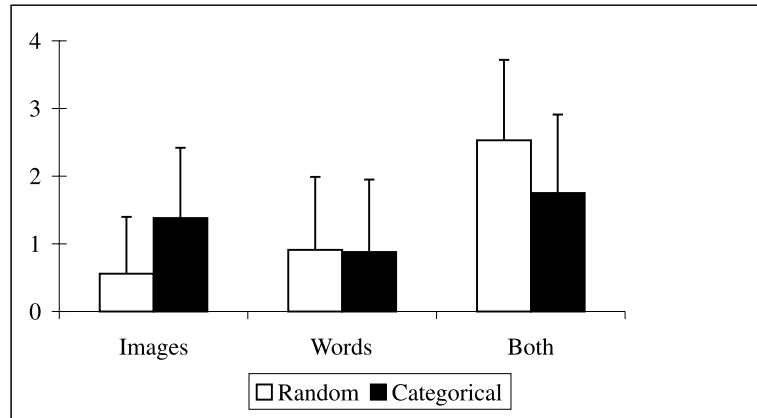


Fig. 2. Experiment Two: The type of experience (image, words or both) reported whilst processing a categorical and a random stimulus organisation. The Y-axis describes the mean likelihood of reporting that type of cognitive experience during the relevant condition.

4. Experiment Three

In the literature on retrieval from memory, there is some debate about whether it is possible to separate the recollection/familiarity influences by task instructions (see Jacoby, 1998). Advocates of this position (Jacoby, 1998; Jacoby et al., 1993) suggest that, irrespective of instructions, all tasks yield retrieval that is based on a combination of recollection and familiarity. To reconcile this view, Jacoby and colleagues suggest it is possible to assess the different components of retrieval by the manipulation of the instructions at retrieval. This is known as the process-dissociation procedure, and is designed to “separate the within-task contributions of the two bases for encoding” (Jacoby, 1998, p. 3). If this position is warranted, then the effects of familiarity in the previous experiment are unlikely to be ‘process pure.’

To account for this possibility, we conducted a further experiment. In this experiment, we utilised the process dissociation procedure (Jacoby et al., 1993), which requires the participants to retrieve information in two conditions. The *inclusion* condition requires the participant to complete a word-stem with any word that comes to mind, regardless of whether the participant believes they saw the word during the study phase, and should therefore include information that is retrieved on the basis of familiarity and recollection. In contrast, the *exclusion* condition requires the individual to complete a word-stem only using information that they did not see during the task. In the latter condition, therefore, any word-stems that are completed with information that was presented at study are likely to be familiar, without being recollected. Using the equations presented by Jennings and Jacoby (1993) we can use retrieval from both of these conditions to calculate the influences of both recollection and familiarity.

A second aim of Experiment Three was to examine the effects of TUT on retrieval in the absence of individual differences. The results of the experiments

Table 3

Experiment Three: The frequency of thinking content (task related and task unrelated) and mood (Hedonic, Tense Arousal, and Energetic Arousal) as measured retrospectively by the DSSQ during the study and test phases of Experiment Three

	Thinking content		Mood		
	Task unrelated thought	Task related interference	Hedonic Tone	Tense Arousal	Energetic Arousal
Encoding	15.8 (4.8)	22.5 (5.8)	23.8 (3.8)	16.9 (5.0)	17.7 (4.7)
Retrieval	10.0 (2.8)*	20.7 (7.0)	23.3 (5.0)	18.3 (5.2)	21.7 (4.5)*

* Significant between task differences ($p < .001$).

presented in this paper and elsewhere (e.g., Smallwood et al., in press-A) involved the comparison of individual differences in the experience of TUT, with differences in retrieval. It is therefore possible that the relationship between TUT during study and the subsequent retrieval of information is a consequence of some unknown tertiary variable, such as response bias (Davies, 1992; Nisbet & Wilson, 1977). To overcome this issue, Experiment Three compared the retrieval of information from those blocks in which TUT was experienced, with the retrieval of information from the totality of blocks in which task related thinking (TRT or TRI) was reported.¹² This comparison would be a within-participants comparison, and would, therefore, make the interpretation that the effect of TUT on retrieval, described in this paper, as a consequence of some broad differences in response bias less likely.¹³ To achieve this comparison, it was necessary to adopt a design in which the base rate of TUT reporting was increased.

To increase TUT likelihood in Experiment Three, we made several design modifications. First, we did not present any stimuli in a categorical format as the results of the two experiments presented in this paper and previous work (Smallwood et al., 2003) suggest that this decreases TUT. Second, previous research has suggested that thinking shifts from TRI to TUT as block length increases in an encoding task (Smallwood et al., in press-B) and therefore Experiment Three required individuals to encode fewer stimuli (10 as opposed to 12) organised in longer blocks (approximately 100 s vs. 70 s). It was anticipated that these modifications would increase the

¹² This type of analysis was first attempted by Teasdale et al. (1995, Experiment Four) and more recently by in a paper presented at the British Psychophysiology Society Annual Conference (Smallwood, 2002). We chose to compare the blocks in which TUT were reported with all other blocks for the following reasons. First, the correlations presented in Experiments One and Two indicated that only the experience of TUT seemed to effect encoding. Second, the comparison maximised the likelihood that we could compare as many individuals as possible using a within-participants design.

¹³ Of course, as TUT cannot be directly manipulated by the experimenter it is always possible that a particular personality trait is responsible for both the experiencing TUT and also impairing the ability of the individual to encode in circumstances of TUT.

frequency with which TUT was reported and thereby facilitate the within-participant comparison outlined above.¹⁴

4.1. Methods

4.1.1. Participants

Thirty-two participants were recruited from the Department of Psychology. Of the 32 participants, 11 were male (approximately 34%) and 21 were female (approximately 66%). Two participants, both female, were excluded from the analysis due to computer error during the study phase. The mean age of the sample was 25.4 years ($SD = 4.7$). As the duration of this experiment was longer than previous experiments due to the extended retrieval conditions, each participant was paid £10 at the end of the experimental session.

4.1.2. Procedure

The procedure employed in Experiment Three was identical to the previous experiments with the following exceptions. All demographic information was obtained at the outset. All words were all presented in blocks of random words.

Study phase. In the study phase of the experiment, each stimulus was presented on the screen for 5 s, with an inter stimulus interval of 5 s. Participants were instructed to read each word and to try and remember the words for a later phase of the experiment. The participants were further instructed to push the space bar as soon as possible after the stimulus disappeared from the screen. The computer recorded the latency of the space bar press. As in previous experiments each block was terminated by a thought probe, which was introduced and classified in the same fashion as in the previous experiment. Following the completion of the study phase of the experiment the participants completed the Thinking Content and Mood Components of the Dundee Stress State Questionnaire (Matthews et al., 1999). The order of presentation of each questionnaire was counterbalanced.

Retrieval phase. The test stimuli contained 100 three-lettered word-fragments divided equally across the exclusion and the inclusion test conditions. Overall each

¹⁴ In addition, there are several minor modifications made to the experimental design concerned with validating the conclusions from previous experiments. To ensure that the ratings of TUT made by the experimenters are valid, we utilised a retrospective questionnaire measure of TUT (the Thinking Content Component of the Dundee Stress state Questionnaire, Matthews, Joyner, Gililand, Campbell, & Faulconner, 1999) which was administered at the end of both the study and retrieval phases of Experiment Three. Should these retrospective measures of thinking correlate positively with the thought probes we would have greater faith in the validity of the thought probe judgements. Moreover, we administered the mood component of the DSSQ to measure self-reported mood during task completion (Matthews et al., 1999) as research indicates that TUT is associated with changes in mood (Seibert & Ellis, 1991; Smallwood et al., in preparation). Finally, during the study phase of the experiment, we measured the participant's attention to the external environment, by requiring the participants to push the space bar when the stimulus disappears from the screen. If TUT does utilise task relevant resources we may expect this latency to be slower during the experience of TUT than during the experience of thinking which is directed towards the task.

retrieval condition contained 32 word-stems that corresponded to items that were previously seen in the study phase and 20 word-stems that corresponded to words that were previously unseen. The instructions for the inclusion and exclusion retrieval conditions were modified versions of the instructions presented by Jacoby (1998).¹⁵ For each test condition, word-stems were presented in two blocks, and therefore the entire retrieval phase consisted of four blocks of 26 word-stems. Between each block, participants were allowed to pause before continuing with the experiment. Word-stem order was randomised within each block and counterbalanced across condition to control for both primacy/recency effects and stimulus specific biases to word-stem completion. Word-stems were presented on screen for a total of 10 s with 1 s between word-fragments. At the end of the four blocks of the test phase, the participants again completed the Thinking Content and Mood Components of the DSSQ.

4.1.3. Measures

To control for the possibility that the results of the previous experiments were consequence of contamination effects based on stimulus effects such as word frequency, the word-lists presented by Jacoby (1998) were used as a stimulus set. The list of 120 was divided into eight lists of 10 words for the purposes of study. From each of the eight lists of words, eight critical stimuli were randomly selected to act as test items. Of the eight critical items for each block, four items were always presented for retrieval in the inclusion condition with the remaining four appearing in the exclusion conditions. The remaining 40 words were divided into two sets of 20 words to be used as new items in the exclusion and inclusion phases of this experiment.

Thought probes were administered as described in Experiment One and inter-rater agreement was 96% for TUT, 85% for TRI, and 82% for TRT. At the end of both the study and test phases of Experiment Three we administered two components of the Dundee Stress State Questionnaire. The Thinking Content component of the DSSQ is a 16-item questionnaire that assesses the content of thinking during a recently completed task and is divided into 2 eight-item factors: (i) task related interference (TRI, e.g., “I thought about how I should work more carefully” or “I thought about my level of ability) and (ii) task unrelated interference (TUI, e.g., “I thought about personal worries” or “I thought about something that happened earlier today”). Both factors are measured on a five point Likert Scale ranging from Never to Very Often.

The Mood component of the DSSQ consists of 29 adjectives (such as happy, nervous or tired). The participant rates the extent to which each word describes how they felt whilst performing the task. Each word is rated on a four point Likert scale and the mood scale contains three factors (Energetic Arousal, Tense Arousal, and Hedonic Tone).

¹⁵ These modifications reflected two aspects of our design: (i) that word-stem completion was initiated by pushing the space bar, and the correct word was typed into the computer, rather than spoken into a microphone and (ii) the stimulus duration for which the word-stems appeared on the screen was shorter, 10 s rather than 15.

4.1.4. Statistical analysis

The statistical analysis for Experiment Three was as follows. First, unlike in the previous experiments we were not concerned with testing the distribution of the thought probes. Instead, we tested the variation in self-reported TRI and TUI using the retrospective data generated by the Thinking Content component of the DSSQ. Previous research (Smallwood et al., 2003, Experiment Three) demonstrated fewer examples of thinking which could be classified as TUT during retrieval compared to encoding. A similar pattern in the data recorded by the retrospective questionnaires would enhance our confidence in the verbal measures of TUT. Second, to examine the consequences of TUT during study on reaction time and memory retrieval, we compared (i) mean reaction time and (ii) the two components of memory retrieval (automatic and conscious) across blocks in which participant's verbal reports indicated TUT with those in which the participant was focused on some component of the current task (TRT and TRI). All of these comparisons were made using repeated measures ANOVA. Finally, for the sake of consistency with the previous two experiments we compared the memory retrieval of those individuals who reported one or more TUTs (TUT group) with those who reported no examples of TUT (NTUT group).

4.2. Results

4.2.1. Task unrelated thought

Given the longer block length employed in Experiment Three, the mean likelihood of an individual reporting a TUT during the study phase of the experiment was higher than in previous experiments. Mean likelihood of reporting a TUT was at 1.73 ($SD = 1.64$), TRI was at 1.65 ($SD = 1.73$), and TRT was at 5.78 ($SD = 2.06$). In total, 20 individuals reported one or more TUTs during the study phase of Experiment Three. Of the sample as a whole the verbal classification of TUT during the encoding phase was strongly associated with the TUI component of the DSSQ from the relevant period ($r = .63, p < .001$) but not associated with the TRI component ($r = -.05, p > .05$). By contrast the classification of TRI based on verbal reports was not correlated with the thought probe classification of TRI as measured by the DSSQ ($r = .15, p > .05$) and was negatively correlated with TUI reported via the questionnaire ($r = -.54, p < .05$).

To compare the effects of task (study vs. retrieval phase) on the experience during task completion we compared the changes in the frequency of retrospective measures of TUT and TRI using two separate repeated measures ANOVA. In line with previous research (Smallwood et al., 2003, Experiment Three) these ANOVAs indicated a significant decrease in retrospectively reported TUT in the retrieval phase of the experiment [$F(1, 30) = 39.78, p < .001$, see Table 3 for the descriptive data] but not for TRI [$F(1, 30) = 2.72, p > .05$]. Out of the three mood dimensions only Energetic Arousal varied across tasks [$F(1, 26) = 9.53, p < .05$].

4.2.2. Reaction time

Twenty individuals reported one or more TUTs in one of the eight thought probes and are included in this section of the analysis. To compare the effects of TUT on the individual's latency to press the space bar after the stimuli disappeared from the screen, we computed the average latency during the blocks during the report of task

Table 4

Experiment Three: The reaction time and likelihood of word-stem completion from blocks in which participants reported TUT and NTUT

	Reaction time (ms)	Recollection	Familiarity
TUT	553 (.04)*	.22 (.06)*	.30 (.04)*
NTUT	513 (.03)	.35 (.05)*	.25 (.03)*

*Significant interaction between the type of thinking and the type of recall ($p < .05$).

focused thinking (TRT and TRI, NTUT Reaction Time) and the average latency during the report of TUT (TUT Reaction Time). Previous research has suggested that the effects of TUT could be observed during the last thirty seconds of a block (Teasdale et al., 1995) and therefore the mean reaction time was calculated over this period of each block.¹⁶ A repeated measure ANOVA indicated a trend towards slower reaction time during the experience of TUT [$F(1, 21) = 3.33, p = .08$]. However, when the age of the participant and the frequency of TUT and TRI reported retrospectively using the DSSQ were included in an ANOVA the main effect of thinking was significant [$F(1, 28) = 6.65, p < .05$, see Table 4] indicating that reaction time latency was measurably larger when a participant reported a TUT. In addition, the ANOVA indicated two further noteworthy effects: (i) a Thought \times Age interaction [$F(1, 18) = 6.40, p < .05$] and (ii) a main effect of TRI frequency [$F(1, 18) = 4.89, p < .05$]. These effects were followed up using partial correlations. When controlling for retrospective TUT and TRI frequency, age was positively correlated with RT whilst experiencing TUT ($r = .46, p < .05$) but not reliably associated with RT whilst not experiencing TUT ($r = -.38, p = .08$). Finally, when controlling for TUT frequency and age, TRI was positively associated with reaction time during both TUT and NTUT blocks ($r = .45, p < .05$ for both types of block).

4.2.3. Memory retrieval

Using the equations presented in Jennings and Jacoby (1993) the automatic and conscious influences on encoding were calculated for each block of the study phase.¹⁷ As for reaction time, these blocks were summated to yield the automatic and conscious influences in blocks in which the individual did report an example of TUT (TUT Recollection and Familiarity) and a second index was calculated to reflect the influences on memory in blocks in which the thinking was directed towards the task (NTUT Recollection and Familiarity). These indices are reported in Table 4. A 2×2 Repeated measures ANOVA were conducted on these indices and yielded no main effects of either influence on retrieval or type of thought. As predicted a Thought \times Type of retrieval interaction was observed [$F(1, 19) = 5.8, p < .05$]. Follow-up analysis indi-

¹⁶ To control for the possibility that extreme reaction times would skew the data reaction times were only recorded for a 1500 ms window following the removal of the stimulus in line with previous work (Smallwood, 2002).

¹⁷ The likelihood of completing a word-fragment in either inclusion and exclusion scores for each type of block (TUT vs. NTUT) was as follows: Exclusion TUT .22 (.19), Inclusion TUT .51 (.24), Exclusion NTUT .17 (.12), and Inclusion NTUT .52 (.12). ANOVA indicated a main effect of recall condition only [$F(1, 20) = 32.6, p < .001$].

cated that the difference between retrieval based on recollection with familiarity was smaller in blocks in which TUT was reported relative to NTUT.

4.2.4. Demographic details

As before the sample was divided into two groups on the basis of the frequency of TUT. Of the TUT group (TUT group, $n = 20$) 14 participants were female, whilst six were male. The mean age of the TUT group was 24.6 years ($SD = 1.6$). In the No TUT group (No TUT group, $n = 10$), five participants were female, and five were male. The mean age of the No TUT group was 25.9 years ($SD = 5.6$). No group differences were observed in the frequency of TRI reported retrospectively by the DSSQ or during thought probes for either the encoding phase or the retrieval phase of the experiment, age or gender ($p > .05$).¹⁸ As in previous experiments the NTUT group reported a higher frequency of TRT [7.20 (.80)] than did the TUT group [5.14 (1.6)]. This difference was significant ($Z = -3.2$, $p < .01$).

As in previous experiments, we compared group differences on memory retrieval to examine whether using the process dissociation procedure, experiencing TUT during study appeared to reduce the ability of the individual to retrieve a stimulus. Using the formula presented by Jacoby (1998) we calculated two separate indices reflecting the automatic and conscious influences on encoding for each individual over the entire task. These indices are presented in Fig. 3B¹⁹ and were compared using a 2 (TUT vs. No TUT) \times 2 (Conscious vs. Automatic) mixed ANOVA. This analysis indicated a main effect of type of retrieval [$F(1, 29) = 12.731$, $p < .001$]. In addition the anticipated Group \times Retrieval interaction approached significance [$F(1, 29) = 3.54$, $p = .07$]. To examine this interaction in greater detail, we conducted two separate ANOVAs in the TUT group and the No TUT group, respectively. This follow-up analysis indicated a strong effect of type of retrieval in the No TUT group [$F(1, 9) = 34.9$, $p < .0001$] and a non-significant effect of type of retrieval in those individuals who reported one or more TUT [$F(1, 20) = 2.2$, $p > .05$]. No effect of TUT group was observed for mean reaction time during the study phase of the task ($p > .05$).²⁰

¹⁸ The distribution of word-stems completed with new items during retrieval was as follows: TUT Exclusion: .49 (.02), TUT Inclusion: .50 (.03), NTUT Inclusion .50 (.03), and NTUT Exclusion .57 (.05). There was no difference for TUT group in terms of the base rate for completing new items in either retrieval condition [$F(1, 28) = 1.39$, $p > .05$] implying that the TUT/NTUT groups did not differ in their ability to generate alternative solutions to the word-stems.

¹⁹ The exact scores across groups in the inclusion and exclusion conditions are as follows: Inclusion TUT .19 (.02) and Exclusion TUT .53 (.02), Inclusion NTUT (.02) and Exclusion NTUT .48 (.04). ANOVA indicated an effect of recall condition [$F(1, 28) = 112.23$, $p < .01$] and a main effect of group [$F(1, 28) = 8.77$, $p < .01$]. No group \times instruction interaction was observed.

²⁰ As in previous experiments, we used correlations to examine the role of task-focused thinking (TRI and TRT) on recall based on either familiarity or recollection. No significant correlations were observed using either the thought report data or the questionnaire measures. In contrast, retrospectively reported frequency of TUT using the DSSQ during the study phase, was positively associated with the likelihood of retrieving information based on familiarity ($r = .36$, $p < .05$).

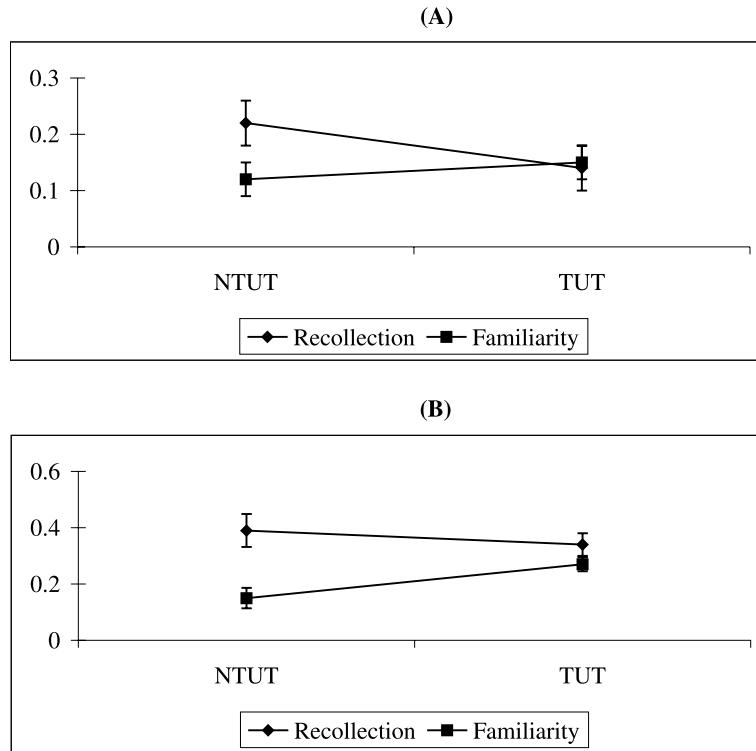


Fig. 3. (A and B) Experiments Two and Three. The Y-axis describes the mean likelihood of correct completion of word-fragments (Panel A, Experiment Two) and word-stems (Panel B, Experiment Three) by those individuals who reported one or more examples of TUT during study (TUT) or those who did not (NTUT). Recollection refers to information which was correctly retrieved, either following an instruction to encode the stimulus at study (Experiment 2) or was retrieved in the appropriate condition (Experiment 3). Familiarity refers to information which was incorrectly retrieved, either following an instruction to ignore the item (Experiment 2) or was retrieved in the incorrect condition (Experiment Three).

4.3. Discussion of Experiment Three

The results of Experiment Three are generally consistent with the results of both previous work on TUT (e.g., Experiment One and Two described in this paper, Smallwood et al., in press-A) and previous work using experimental divisions of attention (Jacoby et al., 1998; Parkin et al., 1990; Szymanski & MacCleod, 1996). In particular, the results of the block-by-block analysis suggest that experiencing TUT during study yields retrieval in which *recollection* and *familiarity* play a comparable role. Moreover, a similar conclusion may be drawn from the group differences presented in Fig. 3B. It is clear, that similar to the results of Experiment Two, individuals who reported one or more examples of TUTs during the study phase, did not show a retrieval advantage due to recollection. Similar to the results of Experiment Two, a recollection advantage during retrieval is clear in the no TUT group.

In addition, the results of Experiment Three provide two important sources of validity for our measure of TUT. First, a reasonable level of consistency can be seen between the verbal coded thoughts and the retrospective questionnaire measure both in their overall agreement ($r = .66, p < .0001$) and in their relationship to memory retrieval (see Footnote 20). This association suggests that there is high agreement between the participants and the experimental team on what constitutes a TUT.²¹ In a similar fashion, the slower reaction time in the blocks in which TUT was reported provides strong construct validity for our classification of TUT.

5. General discussion

5.1. Methodological limitations

Before dealing with the implications of these findings it is worth dealing with several possible problems with the interpretation of the results. A key problem with the data presented throughout this paper is the low base rate in the production of TUT. Whilst the frequency of TUT is higher than that reported by Smallwood et al. (2003) as a result of a higher number of blocks each participant was engaged in, the categorical conditions, in particular, yield lower base rates than described elsewhere (e.g., Teasdale et al., 1993, 1995). Several reasons can be suggested why this may be the case. First, the information processed by the participants was meaningful verbal stimuli that have been suggested to mutually inhibit the production of TUT (Binder et al., 1999). Moreover, the results of these studies demonstrate the role of stimulus organisation in modulating TUT which is only observable during an effortful task (e.g., a memory or fluency task, Smallwood et al., 2003). This can be contrasted with evidence provided elsewhere (e.g., Teasdale et al., 1993) in which a memory task is compared to a rest condition in which the base rate for TUT is much higher. It is likely, therefore, that the investigation of the influence of stimulus organisation in modulating TUT requires the analysis of tasks with reasonably high effort components. By its very nature such an investigation is likely to yield low TUT base rates.

Whilst the low base rate in TUT reported in this paper is a limitation, the replicable effects of TUT during study on subsequent retrieval, go some way to addressing this and other concerns. This paper provides only the third piece of work in which the report of TUT varies consistently with any aspect of task performance (Teasdale et al., 1995, Study Four; Smallwood et al., in press-A). In a high proportion of the literature on TUT (i) the frequency of TUT is significantly higher than that described herein and (ii) performance on the task is normally at ceiling (e.g.,

²¹ At first glance it may seem that a correlation of .66 ($< .001$) does not reflect high agreement. Such a position is however warranted when one considers the fact that over the 20-min task only eight thought probes occur. In contrast, the retrospective questionnaire samples recalled frequency of thinking over the whole task. Consequently the thought probe method will under report thoughts which occur at the beginning of a block, whilst the questionnaire method is contingent upon the individuals memory. Given these differences in sampling a correlation of .66 should be considered reasonably high.

Giambra, 1995; Teasdale et al., 1993). This balance between high TUT rate and the ceiling in task performance precludes any attempt to ensure the validity of the measure of TUT by direct comparison with performance. It is hard to see these issues as mutually exclusive, indeed it seems plausible that to validate a measure of TUT through a comparison with an objective measure of task performance one requires a task in which performance is not at ceiling. Unfortunately, the performance of a task at a level below ceiling is likely to engage strategic volitional resources that reduce TUT, as is probably the case in the experiments reported here and elsewhere (Smallwood et al., 2003). We believe that it is worth sacrificing TUT frequency as the validation of our measure through comparison with performance measures provides strong evidence for its validity. This perspective is strengthened by (i) the strong agreement between the retrospective measures of TUT with the thought probe data in Experiment Three and (ii) the comparable relationships between TUT and memory retrieval, irrespective of method of measurement. From this perspective, the ideal way to proceed in the investigation of TUT is through the analysis of TUT in situations in which (i) the influences on TUT are replicable, and by inference reliable and (ii) the measure of TUT can be validated by comparison with both subjective (self-report) and objective information (e.g., reaction time/memory retrieval). Overall, these factors make it less likely that the findings described in this paper are a consequence of the low base rate or some unknown tertiary variable such as response bias.

6. Speculative conclusions

6.1. TUT and memory retrieval

It is clear that TUT at study is associated with differences in the subsequent retrieval of information. On the one hand, TUT is generally experienced in those situations in which encoding is impaired (such as when encoding non-categorical information, Experiments One and Two; Smallwood et al., 2003, Experiment Three). In a similar fashion, when TUT is experienced it is associated with retrieval from memory in which recollection is not statistically different from retrieval based on familiarity. What is less certain is whether the effects of TUT upon retrieval are directly comparable with the effects of divided attention.

Experimental divisions of attention, impair recollection, whilst leaving retrieval based on familiarity unaffected (Jacoby et al., 1998; Parkin et al., 1990; Szymanski & MacCleod, 1996). By contrast, our data are less conclusive. The block-by-block analysis suggests that TUT during study yields a pattern of retrieval, which is characterised by a shift towards (i) lower retrieval based on recollection and (ii) higher retrieval based on familiarity. In contrast, Fig. 3B indicates, that over the task as a whole the TUT groups retrieve information based on familiarity at a level comparable with the frequency with which they retrieve information on the basis of recollection.

Several reasons can be suggested to account for these differences. It is common in divided attention tasks to demonstrate that the individual attends to the dual

channels of information, by publishing data such as mean number of targets detected the secondary task (see Jacoby, 1998). To treat TUT as a simple division of attention in this fashion is overly simplistic. First, TUT frequency is only indirectly under the control of the experimenter, unlike a traditional division of attention, and it is, therefore, possible that the differences in the effects of TUT are a result of the numerical inequality between the frequency of blocks of TUT and those in which task focused thinking is reported (TRT and TRI).

Second, TUT is not open to observation, and therefore we cannot ensure that all individuals attend to their cognitive experience in a similar fashion. In fact wide, individual differences in ones tendency to daydream are very likely (see Giambra, 1995). In the real world these differences are unlikely to be limited to the frequency of TUT, and in fact evidence suggests that day dreaming may play an important role in the development of psychopathology (Greenwald & Harder, 1995, 1997; Teasdale, 1989) and, more generally, in the development of personality as a whole (Klinger, 1999; Shoda & Mischel, 1998). Given these perspectives on daydreaming, it seems likely that the experience of TUT is associated with a variety of different influences on concurrent information processing. One possibility is that the individual differences associated with TUT are also associated with fundamental differences in the ability to maintain exogenous attention; a pre-requisite of satisfactory encoding in the first instance.²²

Finally, it is possible that the difference between TUT and divisions of attention concerns the nature of the material processed. Unlike divided attention tasks, in which the secondary task is often relatively mundane, such as monitoring a stream of digits, experiencing TUT often involves the processing of material that is of high personal consequence (Greenwald & Harder, 1995, 1997; Klinger, 1978; Klinger et al., 1980). A large body of evidence suggests that emotive material tends to attract the attention of the individual (e.g., Ohman, Flykt, & Esteves, 2001) and may do so in an automatic fashion (MacLeod, 1991; Martin, Williams, & Clark, 1991; McKenna & Sharma, 1995). If the information processed during the experience of TUT does represent the processing of emotionally arousing information, *the individual's current concerns*, then it is plausible that the emotional tone of the information processed is responsible for the different pattern of retrieval. This position is supported by some recent work (Smallwood, O'Connor, Sudberry, & Obonsawin, in preparation²³). Using the block-by-block technique described in Experiment Three, we observed elevations in heart rate and galvanic skin response in the blocks in which TUT was reported relative to those blocks in which task focused thinking was reported. These changes reflect physiological changes that are associated with higher emotional arousal.

²² It has been suggested that daydreaming is associated with depression (Greenwald & Harder, 1995, 1997; Teasdale, 1989) and would therefore co-vary with various aspects of depressive phenomenology. Reasonably well-researched components of the phenomenology of depression are (i) an impairment in encoding/retrieval (see Hartlage, Alloy, Vazquez, & Dykman, 1993 for a review) and (ii) over-general memory (Williams & Scott, 1988).

²³ This research was presented as a paper at the European Society for The Philosophy of Psychology Annual Conference, 2002, Lyon.

Despite the differences between the experiencing TUT and traditional tasks of divided attention, it is clear that parallels between the two conditions can be drawn. Whilst, any attempt to isolate the effects of TUT during encoding must remain speculative, it is reasonable to assume that experiencing TUT during study is associated with measurable changes in one's ability to subsequently retrieve information. These differences are replicable, reasonably consistent and whilst demand characteristics cannot be entirely ruled out, they are unlikely to contribute to the effects presented in this paper.

6.2. *Holistic processing and subjective experience*

As has been suggested elsewhere (Smallwood et al., 2003) the literature on TUT suggests two apparently contradictorily influences on the report of TUT: (i) the effort required to complete the task (Giambra, 1995) and (ii) stimulus features such as semantic content (Binder et al., 1999) or stimulus organisation (Smallwood et al., in press-A): both *higher order stimulus features* (Kanwisher, 2001). These influences are contradictory because a distributed resource needs no central executive (Kennephol, 1999; Smolensky, 1999). Distributed accounts of thinking can explain the effects of categories on thinking (Smallwood et al., 2003). In contrast, the concept of 'effort' is useful in describing how low-level stimulus characteristics, such as stimulus presentation rate (Giambra, 1995) may moderate thinking.

The results of Experiment Two, however, provide a challenge to both perspectives. The results of Experiment Two indicate the effects of stimulus organisation on TUT should be considered an interaction between (i) the presentation of a stimulus set which affords the participant with stimuli that can be easily encoded and (ii) by whether the participant is required to actively engage with the task stimuli. In short, the effects of both effort and context on TUT are contingent upon each another.

How might we understand how the interaction between these apparently contradictory influences? One possible clue may be gained from the distribution of type of experience reported in the two stimulus organisation across Experiment One and Two presented in this paper (e.g., Figs. 1 and 2). In both Experiments One and Two, the random stimulus organisation was exemplified by an experience consisting of both images and words. Moreover, those individuals who experienced more than one example of TUT in Experiment One reported fewer experiences consisting of both words and images whilst encoding random information, and were less accurate in their retrieval. Given the well-documented role of imageability in determining a participant's ability to retrieve a stimulus (Bower, 1970; Paivio, 1965) it seems reasonable that the pattern between increased TUT and subjective experience of both images and words whilst encoding random information is more than an artefactual correlation. It is plausible that to encode information presented in a random stimulus organisation the participant will attempt to engage an encoding strategy that maintains task focus by encoding the information as holistic or gestalt. Such an encoding strategy is less critical for a categorical stimulus organisation as the stimulus units, by their very nature, readily form a conceptual whole. In short, it may be speculated that as in the same way the *macro* holistic features of a task, such as stimulus organisation (Smallwood et al., 2003), semantic information processing

(Binder et al., 1999) or the role of interest in a piece of text (Grotsky & Giambra, 1989), may modulate thinking, an individual's strategy may play a similar role, at the *micro* level.

An attempt to bind or 'blend' the stimuli in a random stimulus organisation into a holistic multi-dimensional whole is reminiscent of the 'binding problem' associated with conscious awareness (Crick, 1994, p. 208). Crick argues that the experience of a coherent whole requires several multi-dimensional streams of information to be bound together into a conceptual gestalt. It seems a plausible hypothesis that those individuals who successfully maintained their attention on the task in hand in the random condition in Experiment One did so by successfully generating a holistic 'multi-dimensional' representation of the stimuli as they were experienced. A categorical stimulus organisation would clearly enhance this process because the meaningful associations within the stimulus set would facilitate the online integration of the external and internal contexts of information processing (Baars, 1988).

At present, this must remain speculative as the critical finding, namely that those individuals who reported more than one TUT reported a lower proportion of words and images, during the random stimulus organisation, was not replicated in Experiment Two. The lack of replication is almost certainly a consequence of the fact that only half of the blocks in Experiment Two required participants to encode information relative to Experiment One, yielding a less powerful test of the hypothesis. Moreover, and more prohibitive for a robust understanding of TUT, in the present design the relationship between content of thought and the type of experience is correlational and cannot be directly manipulated by the experimenter. It is important to therefore investigate the relationship between encoding strategy and TUT in an explicit fashion to examine if the hypothesised relationship between multi-dimensional binding can be experimentally manipulated.

Future research, therefore, should focus on how both distributed and encapsulated models of cognition might interact to produce the phenomenon of TUT. Dennet (2001) proposes a notion of consciousness in which different sources of information compete for attention based on (i) either a quality of the stimulus, such as importance or (ii) through a need basis (such as the classical role that effort plays in a classical limited processing account of cognition).²⁴ Experimental evidence has previously demonstrated support for the role of either environmental influences such as stimulus organisation (Smallwood et al., 2003) or effort (Giambra, 1995; Teasdale et al., 1993) in isolation. The results of Experiment Two demonstrate how these two influences may interact and through their interaction moderate the experience of TUT. An understanding of these interactions may ultimately allow the competing influences on human information processing to be reconciled.

²⁴ A more explicit account of the interaction between qualitatively different codes of information is Interacting Cognitive Subsystems (ICS, Teasdale & Barnard, 1993). The ICS framework provides a model of how qualitatively different codes of information may interact, a process known as *buffered processing*. In addition, a biologically plausible account of these issues may be found in the work of Miller and colleagues (Miller, 2000; Miller & Cohen, 2001).

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