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The consequences of encoding information on the maintenance of internally generated images and thoughts: The role of meaning complexes

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Abstract

Three experiments investigated the hypothesis that internally generated images and thoughts were driven by *meaning complexes*, a construct which reflects a synthesis of semantic meaning and personal salience (Klinger, 1999). Experiments 1 and 2 contrasted the mutual inhibition between encoding words and non-words on: (i) the frequency that thoughts and images unrelated to the task (task unrelated thought, TUT) were experienced (Experiment 1) and (ii) on the intensity of images generated from long-term memory and maintained under dual task conditions, which whilst familiar were not of particular personal salience (Experiment 2). Experiment 3 examined the physiological arousal associated with the experience of TUT in a semantic encoding task. Evidence suggested that, in general, internally generated images and thoughts, irrespective of the personal salience, were suppressed by the co-ordination of information in working memory. In addition, only the experience of spontaneous images and thoughts of personal salience (TUT, Experiments 1 and 3) interfered reliably with the encoding/retrieval of semantic information from memory. Finally, in Experiment 3, physiological arousal, as indexed by mean heart rate, was associated with a high frequency of TUT. The results of all three experiments support the notion that the maintenance

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of spontaneously occurring images and thoughts is simultaneously influenced by both the semantic content and the personal salience of the information held in working memory.

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1. Introduction

When engaged on a task, one's attention can be directed externally towards task relevant material or alternatively can be directed internally, such as when one is involved in a daydream. Several authors have suggested that an internalised focus to attention, consistent with daydreaming, may be associated with important functional consequences, such as facilitating problem solving via the conceptual manipulation of semantic information (Baddeley, 1999; Binder et al., 1999). This position is exemplified in the following quotation: "By storing and manipulating internal information 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). One possible advantage of these internal processes is that they facilitate problem solving in the less hazardous environment of the neural workspace (Cleeremans & Jiménez, 2002; Dehaene & Naccache, 2001).

The subjective experience of internally generated images and thoughts can be understood in terms of a competitive process within the attention of the individual with both *internal* influences, such as current concerns (Klinger, 1999), dysphoria (Smallwood et al., 2004b) or current mood (Seibert & Ellis, 1991) and *external* influences, such as presentation rate (Antrobus, 1968), task (Teasdale, Lloyd, Proctor, & Baddeley, 1993), length of testing session (Smallwood, Obonsawin, & Reid, 2003c) or demand characteristics, dominating at various times (Antrobus et al., 1999). However, much of the mental content is derived internally without any overt cue (Klinger, 1999). Estimates suggest that approximately 20% of thoughts recorded during a laboratory task were unrelated to the current setting (Klinger, 1978), although this proportion is probably higher than in an everyday setting (Klinger & Cox, 1987). Hence, under laboratory conditions internally focused attention can be described as a situation in which "the attention of the individual becomes to some extent decoupled from the processing of external perceptual information" (Smallwood, Baraciaia, Lowe, & Obonsawin, 2003b). To account for the internal, *stimulus-independent* influences on attention it has been suggested that they can be understood in terms of the notion of *meaning complexes*: a higher order construct which can be seen as a synthesis of the notion of semantic meaning and the individual's intentions or *current concerns* (Klinger, 1999). In the subsequent sections of this paper, we review evidence which supports the importance of both components of *meaning complexes* in internally generated information: (i) the personal salience of the information and (ii) the semantic nature of the information.

1.1. Daydreaming and personal salience

1.1.1. Daydreaming reflects the processing of one's current concerns

Perhaps the most obvious link between internalised attention and meaning complexes comes from the association between daydreaming and the individual's current concerns. *Current* *concerns* can be considered to reflect the "hypothetical process active during the time that one has a goal" (Klinger, 1999, p. 439). In short, current concerns reflect the notion that many human goals extend beyond any given situation and that these goals need to be maintained in the mind of the individual, possibly in an unconscious form (Klinger, 1999). Thus one perspective on daydreams is that they represent the "unfinished business" of the individual (Singer, 1966).

Evidence from both naturalistic (Klinger, Barta, & Maxeiner, 1980) and laboratory settings (Klinger, 1978) suggest that when an individual's attention is directed internally they are likely to be processing their *current concerns* (Klinger, 1999). First, when thinking was sampled on a day-to-day basis through the use of a pager the content of the participant's thinking was often associated with the contents of their current concerns as sampled by a questionnaire. These concerns can be associated with the individual's present life (67%), past or future (12%) or no particular time period (23%; Klinger & Cox, 1987). Second, an experimental induction which induced a personal salient concern with extensive implications for an individual, in this case a broadcast indicating that China had entered the Vietnam war, increased the likelihood of task unrelated thinking (0.32–0.45) and the frequency of errors (.045–.055), relative to a neutral control broadcast (Antrobus, Singer, & Greenberg, 1966).

Similarities can also be seen in the overlap between the content of one's daydreams and the coping strategies that one employs on a day-to-day basis (Greenwald & Harder, 1995, 1997). These studies indicated that a consistent and reliable association could be observed between the content of daydreams experienced on a day-to-day basis and the content of sustained fantasies evoked in situations of distress as a source of comfort to the individual (Greenwald & Harder, 1995). For example, a high frequency of daydreams with a hostile content was associated with sustained fantasies at a time of crisis with a similar content. In a follow-up study, this finding was broadly replicated and the authors demonstrated additional overlap with the coping strategies employed by individuals. In this context, a high frequency of daydreams was associated with the employment of a coping strategy in which the individual "thinks endlessly" about a problem (Greenwald & Harder, 1997). These results suggest that, in addition to a process by which they refresh one's awareness of one's current concerns (Klinger, 1999), the experience of a daydream may allow the individual to mentally rehearse the coping strategies that they employ on a day-to-day basis (Greenwald & Harder, 1995, 1997). In either case, therefore, from a theoretical perspective, daydreams are likely to entail a strong motivational component because they reflect the processing of information of personal salience to the individual.

1.2. Daydreaming and information processing

Evidence from the investigation of thinking via the use of thought probes has implicated the co-ordination of information in working memory in the experience of a daydream (Smallwood, Obonsawin, Reid, & Heim, 2002, 2003a, 2003b, 2003c; Teasdale et al., 1995). In these experiments a shift in attention is measured through the use of a thought probe which terminates the current block of the task Teasdale et al. (1993, 1995; Smallwood et al., 2003a, 2003b, 2003c). 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[2]; TUT, see Smallwood et al., 2003c for detailed criteria on making these judgements).

As the notion of meaning complexes implies the experience of TUT can be considered a situation in which the content of awareness departs from task relevant information processing (see Smallwood et al., 2003a, 2003b) and instead working memory resources becomes directed towards internally generated information of personal salience (see previous section). Evidence for this assumption comes from three sources: (i) tasks which require the co-ordination of information in working memory interrupt the genesis of TUT (see Smallwood et al., 2003a, 2003b, 2003c; Teasdale et al., 1993, 1995) and (ii) when the attention of the individual strays from the task and the individual experiences TUT their performance on the secondary task should suffer (Smallwood et al., 2002, 2003b; Teasdale et al., 1995), and (iii) perhaps the most direct source of support for the role of working memory resources in the experience of daydreaming comes from a series of studies in which daydreaming impaired text comprehension (Schooler, 2002; Schooler, Reichle, & Halpern, in press).

1.2.1. Co-ordinating information in working memory suppresses task-unrelated thought

Consistent with the perspective outlined in this paper, tasks which require the co-ordination of information in working memory suppress the experience of TUT. For example, when presented with information for subsequent retrieval TUT is experienced at a lower frequency than when shadowing the same information, irrespective of the length of the digit string (Teasdale et al., 1993). In addition, articulatory suppression and rehearsal of a 5-digit load (Experiment 1) and a spatial motor task (Experiment 2) significantly reduced the frequency of TUT relative to a control task (Teasdale et al., 1995). Similarly, recalling a list of verbal stimuli yields lower frequencies of TUT than encoding the same stimuli, irrespective of the method of measurement of subjective experience (Smallwood et al., 2003a, 2003b). Moreover, as the central executive is thought to play a progressively smaller role as time on task increases (Baddeley, 1999) it is relevant that TUT increased with prior practice on both a pursuit rotor task and a memory load task (Teasdale et al., 1995, Experiment 3). Consistent with this finding the frequency of TUT was unaffected by the length of the block when generating verbal information (Smallwood et al., 2003c), whilst longer block lengths led to measurable increases in the frequency of TUT in both encoding and vigilance tasks. Overall, therefore, evidence supports the assertion that when the external task requires the co-ordination of information in working memory, the frequency with which TUT occurs is low (Smallwood et al., 2003a, 2003b, 2003c; Teasdale et al., 1993, 1995).

1.2.2. Experiencing task-unrelated thought impairs the co-ordination of task relevant information in working memory

A second prediction, consistent with the pattern of mutual inhibition between daydreaming and external task performance, is that when the individual's attention strays from the task, and they experience TUT, their performance on the secondary task should suffer (see Baddeley, 1993). Consistent with this prediction, experiencing TUT whilst engaged on a random generation task was

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[2] Similar to Antrobus (1999) we prefer the notion of task unrelated thought to the term stimulus independent thought because TUT is consistent with the fact that no thought is truly unrelated to a stimulus (Antrobus, 1999, p. 11). Broadly, however, both stimulus independent thoughts and task unrelated thoughts refer to the same phenomenon.

associated with impairment in the individual's ability to generate random sequences (Teasdale et al., 1995, Experiment 4). In addition, experiencing TUT whilst encoding verbal information, led to: (i) a shift in retrieval response towards retrieval of information on the basis of familiarity, rather than recollection and (ii) an increased reaction time during study (Smallwood et al., 2003b). These impairments in task performance are in contrast to a large body of evidence that suggests that TUT during vigilance has little or no implications for task performance (e.g., Antrobus, 1968; Giambra, 1995; Grodsky & Giambra, 1989; see also Teasdale et al., 1993). Moreover, whilst recent work has implicated the experience of TUT in vigilance performance (Smallwood et al., 2004a), this detriment was limited to successive vigilance. As successive vigilance tasks require the participant to "discriminate between a currently viewed stimulus and a standard representation of a specific stimulus held in working memory" (Desmond, Matthews, & Bush, 2001, p. 1386) whilst in simultaneous vigilance "all of the necessary information to make the discrimination is presented in the current field" (Desmond et al., 2001, p. 1386). This finding provides further support for the notion that daydreaming monopolises working memory resources and prevents the co-ordination of task relevant information towards task completion.

1.2.3. Task-unrelated thought interferes with text comprehension

The final source of evidence to indicate that daydreaming interferes with the co-ordination of information in working memory comes from the analysis of daydreaming during text comprehension (Schooler, 2002; Schooler et al., in press). The co-ordination of information in working memory has been implicated in the comprehension of text (Daneman & Carpenter, 1980; Gathercole & Baddeley, 1993; Just & Carpenter, 1992; Oakhill, Yuill, & Parkin, 1986, 1988) and the role has been described as follows: "Processing is needed to recognise the lexical items represented by the surface forms of language, access their syntactic and semantic specifications and interpret the meanings of sentences" (Gathercole & Baddeley, 1993, p. 222). In this context it is relevant that work by Schooler et al. (in press) identified that daydreaming during text comprehension was associated with periods of low comprehension. In the words of Schooler et al. (in press), during reading comprehension"Your eyes may continue moving across the page, the phonology of the words may continue sounding in your head, yet fundamentally your mind may be elsewhere."

Not only, therefore, is the experience of TUT less likely when the task requires the co-ordination of information towards task completion, but when TUT is experienced it can lead to a measurable impairment in the co-ordination of task relevant material in working memory, either in terms of: (i) our ability to generate random sequences (Teasdale et al., 1995, Experiment 4), (ii) our ability to encode the stimulus in the first instance (Smallwood et al., 2002, 2003a, 2003b) and (iii) our ability to extract higher-order meaning from the text (Schooler et al., in press). Thus empirical evidence suggests " when one is paying attention to external events one cannot let ones mind wander; or conversely if ones mind wanders one is not paying attention (Antrobus, 1999, p. 8).

It is clear that existing evidence supports the notion that "meaning complexes" (Klinger, 1999) can be considered to play an important role in the internal regulation of the information in working memory. First, evidence suggests that the content of daydreams tend to be highly salient to the individual (Greenwald & Harder, 1997; Klinger et al., 1980). Second, the experience of TUT competes for working memory resources and therefore interferes with our ability to co-ordinate task relevant information (Antrobus et al., 1966; Teasdale et al., 1995). Recent work has demonstrated that this detriment extends beyond simple sensorimotor tasks such as that employed by Antrobus (1968) and TUT has been shown to interfere with an individuals ability to derive complex semantic information from a stimulus (Smallwood et al., 2002; Smallwood et al., 2003b; Schooler et al., in press).

1.3. Current experimental aims

The experiments presented in this paper are concerned with directly evaluating the role that "meaning complexes" (Klinger, 1999) play in the maintenance of internally generated streams of information. As the content of awareness of an individual can be conceptualised as a competitive process between internal and external stimuli (Antrobus, 1999) we can derive a series of hypotheses about the conditions that promote the experience of TUT and the consequences of this state of mind. First, if internal experience does involve a semantic component, then the task of coordinating semantically rich task relevant information in working memory should interfere with the experience of TUT. This relationship is qualified, however, because experimental evidence suggests that the relationship is one that may represent an *affordance* (Smallwood et al., 2003b, 2003c). That is, merely experiencing semantic information is not likely to disrupt the experience of TUT, instead the participant needs to engage with the stimulus materials (see Smallwood et al., 2003b, Experiment 2; see also Teasdale et al., 1993). In all three experiments presented in this paper, therefore, we examine the mutual inhibition between the encoding of semantic information from the external environment on the experience of internally generated images. In these experiments, this mutual inhibition can be operationalised in two dimensions as: (i) a lower frequency of TUT (Experiment 1)/less vivid internally generated images (Experiment 2) and (ii) the experience of the internally generated images should yield an impairment in the ability to encode stimuli from the environment.

Second, because the spontaneous streams of thought, such as TUT, reflects the processing of one's current concerns, the internal information should reflect the processing of personally salient information. A large body of evidence suggests that emotive or highly salient 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). It follows, therefore, that "if the emotional arousing stimuli are central to the task and are therefore at the focus of processing—they facilitate perceptual and attentional responses. If on the other hand, incidental stimuli are emotionally arousing, they distract from the target task" (Klinger, 1999, p. 36). The previously mentioned study by Antrobus et al. (1966) provides support for this notion because the experimental induction which induced personal concerns produced both: (i) elevations in TUT and (ii) increases in errors. On this basis, it is probable that some of the interference between TUT and an external task, as described in the literature (Antrobus et al., 1966; Schooler et al., in press; Smallwood et al., 2002; Smallwood et al., 2003a, 2003b; Teasdale et al., 1995, Experiment 4), is a result of the personal salience of the information maintained in working memory.

We addressed the role of personal salience in a different manner in each of the three experiments presented in this paper. In Experiment 1, we investigated the role that dysphoria plays in the generation of TUT. Dysphoria can be considered to be a state in which the current self departs from the ideal self (Pyszczynski & Greenberg, 1987), and consistent with this notion, research has demonstrated that dysphoria but not rumination is associated with high levels of TUT (Smallwood et al., 2004b; see Smallwood, O'Connor, & Heim, submitted for a replication; see also Seibert & Ellis, 1991). On this basis we hypothesised that consistent with previous research, the experience of TUT would be associated with higher levels of dysphoria (Experiment 1). In the second experiment, we examined the consequences of processing internally generated information on the vividness of images that are not personally salient. If, as suggested by Klinger (1999) and others, daydreams have an important influence on information processing because they are emotionally significant to the individual, one could hypothesise lower levels of mutual inhibition between internally generated images in Experiment 2, because whilst they are familiar they are not personally salient to the individual. Finally, in Experiment 3 we measured the physiological arousal that occurs during a semantic encoding task. Previous research has suggested that in circumstances in which the report of TUT was expected to be less frequent was associated with reductions in physiological arousal (Antrobus, 1973; see also Antrobus, 1999). We hypothesised that, if TUT was associated with the individual's current concerns, we would be able to detect a positive association between TUT and measures of physiological arousal.

1.4. Methodological considerations

The study of the maintenance of internal streams of information requires the investigation of subjectively reported information. With such a study, it is important to validate the subjective information reported by the individuals during task completion by reference to measurable aspects of task processing (Baars, 1988). In particular, two criteria have been provided to validate the verbal reports provided during the investigation of TUT in the context of laboratory tasks (Smallwood et al., 2003b). First, when classifying thinking, in addition to high levels of inter-rater consistency, it is important to validate the coding employed by the judges through comparison with retrospective measures completed by the participants themselves. Reasonable agreement between these two sources of information would suggest that there was agreement between experimenters and the participants on the contents of thinking. In Experiment 1, we demonstrate reasonable correspondence between these two forms of measurement of TUT. Second, it is important to identify the consequences of the subjective state on concurrent information processing, such as a meaningful correspondence between experiencing TUT during encoding and the subsequent retrieval of information from memory presented in the literature (Smallwood et al., 2002, 2003b). Such a correspondence between verbal response and behaviour provides evidence that the experience of TUT is more than a verbal label applied by experimenters—it has actual consequences for ongoing task completion.[3] Finally, in Experiment 3, we demonstrate that high levels of physiological arousal, as measured by heart rate, is associated with high frequencies of TUT. This provides an important alternative source of validation because the activity of the autonomic nervous system is less available to conscious control than either measures of retrospective self-report or task performance.

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[3] To avoid a confound regarding demand characteristics it is important to make this comparison within rather than between participants. A within participant comparison ensures that individual differences in the adherence to experimental instruction are not responsible for the differences observed.

2. Experiment 1

2.1. Aim

The first aim of Experiment 1 was to investigate whether the experience of TUT would be contingent upon the semantic content of the external task. To achieve this aim we compared TUT across three conditions: (i) encoding words, (ii) encoding non-words, and (iii) during vigilance. If TUT reflects the co-ordination of semantic information an implication of the notion of meaning complexes, the fewest examples of TUT should be reported whilst encoding words. In addition to the comparison of the distribution of the frequency of TUT, we also compared the effects of experiencing TUT on: (i) subsequent memory retrieval and (ii) reaction time as a measure of exogenous attention. We anticipated that, consistent with previous work (Smallwood et al., 2003c; Smallwood et al., 2004b, Experiment 3), experiencing TUT would be associated with slower concurrent reaction time and fewer correctly completed word stems during subsequent retrieval. The second aim Experiment 1 was to examine the role of *current concerns* (Klinger, 1999) on the experience of TUT. It was anticipated that consistent with previous work (Seibert & Ellis, 1991; Smallwood et al., 2004b) high levels of dysphoria would correspond to an elevated frequency of TUT.

2.2. Methods

2.2.1. Participants

Thirty healthy participants were recruited from a University Psychology Department. The mean age of the sample was 34.5 years (*SD* = 10.0) and each participant had spent approximately 16.8 years (*SD* = 3.37) in full time education. Of the sample, eight participants were male and 22 were female. Ethical approval had been obtained from the University Psychology Department's ethics committee.

2.2.2. Materials

Stimuli for the encoding and retrieval phases of the word condition were selected from the norms presented by Jacoby (1998). All stimuli employed in Experiment 1 were five letters long such as Actor or Cloth. Stimuli presented in the non-word condition were adapted from the non-words presented by (Bird & Williams, 2002). To ensure that in each condition stimuli with the same length were presented, the non-word stimuli were modified so that they all contained five letters. Examples of the non-words included Ralin or Flase. In total, fifty words and non-words were presented during the study phase of Experiment 1 in five blocks of ten stimuli. Of these ten stimuli, four critical stimuli were selected at random and presented as three letter word-stems during the retrieval phase of the experiment. In the vigilance task, the background stimulus was 'XXXXX' whereas the target stimulus was 'OOOOO.'

In addition to the three tasks, participants completed a battery of four questionnaires to measure: (i) depression, (ii) rumination, (iii) mood, and (iv) thinking content. First, the Centre for Epidemiological Studies Depression Inventory (CES-D; Radloff, 1977) is a measure of dysphoria validated for use with an undergraduate sample and contains twenty items which assess the frequency with which various self-descriptive terms can be applied to oneself over the last week.

The CES-D is measured on a four point Likert scale and contains items such as "I was bothered by things which did not normally bother me." Second, the short form of the Response to Situations Questionnaire (RSQ; Nolen-Hoeskema, 1991) is a 10-item measure of trait rumination which assesses how an individual tends to respond when they are feeling depressed. It contains items such as "I think about how alone I feel" or "I think about how hard it is to concentrate." Each item is measured on a four point Likert scale.

Finally, we administered two components of the Dundee Stress State Questionnaire (DSSQ; Matthews, Joyner, Gililand, Campbell, & Faulconner, 1999) which is a self-report instrument designed to measure subjective experience during a recently completed task. For the purpose of this experiment we selected two components: (i) Mood and (ii) Thinking Content. The Mood component of the DSSQ consists of twenty-nine adjectives (such as happy, nervous or tired). The participant rates the extent to which each adjective 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).

The Thinking Content component of the DSSQ is a sixteen-item questionnaire that assesses the content of thinking during a recently completed task and is divided into two 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[4]; 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 anchored at Never and Very Often.

2.2.3. Procedure

In all three tasks each stimulus was a five letter alphanumeric string presented in the centre of the computer screen. Regardless of task, all stimuli were presented in blocks of ten sequential stimuli. Stimuli were presented on the screen for 5 s, with an inter-stimulus interval of five seconds. Each participant completed five blocks of each task before moving on to the next task. Order of blocks and tasks was fully counterbalanced. In all blocks stimulus order was randomised and the computer recorded the latency of the space bar press.

2.2.3.1. Words and non-words. Participants were instructed to read each item silently and to try to remember the items for recall at a later phase of the experiment. The participants were further instructed to push the space bar as soon as possible after the item disappeared from the screen.

2.2.3.2. Vigilance task. During the vigilance task, participants saw a series of five letter strings appear sequentially on a computer screen. Participants were informed that they should push the space bar, whenever five Xs disappeared from the screen (XXXXX). They were informed that sometimes the stimulus would be five Os (OOOOO) in which case they should not push the space bar when the stimulus disappeared from the screen. This type of vigilance task is known as a sustained attention to response task (Robertson, Manly, Andrade, Baddeley, & Yiend, 1997) to emphasise that attention must be directed to the response as well as the target. We opted to employ this form of vigilance task because it ensured a high frequency of responses on behalf of the individuals, thereby maximising the reliability of the reaction time data collected. In each block of

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[4] For the sake of simplicity, we will refer to these thoughts as retrospective TUT.

the vigilance task, 2 out of 10 stimuli were targets (20%, see Smallwood et al., 2004a for a series of investigations into the experience of TUT during this task).

Following the completion of all three conditions, 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.

2.2.3.3. Retrieval phase. Memory retrieval was measured via word-stem completion using a paper and pencil test and measured directly after completion of the questionnaires. The four critical stimuli from each block of words and non-words (20 in each case) were presented with an equal number of 'new' word stems presented on a single sheet of paper. These new items could not be completed with information presented in the task. The order of stimuli on the sheet was randomised. At the outset, participants were informed: "The following list of items can be completed to create words or non-words by filling in words in the blanks. Please complete the following items with letters to create words or non-words you saw in the experiment. Some of these items were shown and some were not. Try not to complete words/non-words that you did not see. Only create items that you did see." Participants were allowed a maximum of five minutes to complete the retrieval phase of the experiment. At the end of the experimental session the participants completed the final two questionnaires (CES-D and RSQ).

2.2.3.4. Thought probes. Before beginning the experimental session, each participant was informed that:

> When you see the word STOP appear on the screen I would like you to stop what you are doing and tell me exactly what is 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."

2.2.3.5. Thought classification. Thoughts were recorded verbatim and later classified by the examiner and by two judges blind to the hypotheses of the experiment. Thoughts were classified into two broad categories. First, thoughts were classified to reflect whether they were directed towards matters unrelated to the task in hand, Task Unrelated Thought (TUT). 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." All other thoughts reflected some degree of attention to the current environment or the task in hand (No Task Unrelated Thought, NTUT).[5] The total number of recorded thoughts per condition was five, and therefore, fifteen thoughts per individual were recorded for analysis. Inter-rater agreement was 94%.

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[5] In this experiment we opted not to classify thinking in terms of the extent to which it was concerned with the appraisal of the self/task as in previous work, a phenomenon known as task-related interference (Smallwood et al., 2002, 2003a, 2003b). A detailed examination of both verbal reports and retrospective questionnaire data suggests that only the experience of task-unrelated thinking makes a measurable contribution to concurrent encoding (Smallwood et al., 2002, 2003b). Moreover, in terms of consistency with the subsequent experiments, we are concerned with the process by which internally generated streams of information are maintained in the absence of external stimulation. For both of these reasons we, therefore, opted to code thoughts only in terms of whether they were concerned with matters unrelated to the current situation.

Table 1
Frequency of TUT and mean reaction time across the three conditions: (i) words, (ii) non-words, and (iii) vigilance

Task	Frequency		Reaction time (ms)				Effects of TUT on reaction time (ms)	
	Mean	*SD*	TUT		NTUT		Mean	*SD*
			Mean	*SD*	Mean	*SD*		
Words	.14*	.03	730	12	601	04	+130*	09
Non-words	.22	.04	608	05	595	09	+13	06
Vigilance	.29*	.05	729	09	726	08	−03*	03

* Significant difference between tasks ($p < .05$).

2.3. Results

Over the course of the vigilance task all participants detected all targets. Overall the likelihood of correctly completing a word-fragment with information presented whilst encoding words [*Mean* = .40 (*SD* = .03)] was higher than for non-words [*Mean* = .07 (*SD* = 0.01)]. This difference was reliable [$t(30) = 10.739$, $p < .001$]. There was no difference between the likelihood of making an erroneous stem completion by condition [Words: *Mean* = .15 (*SD* = 0.12); Non-words: *Mean* = .16 (*SD* = 0.11), $t(29) = .101$, $p > .05$].

2.3.1. Distribution of TUT

Table 1 describes the distribution of TUT. Across the sample, as a whole, a strong correspondence was observed between the classifications of TUT made by the independent judges and the retrospective questionnaire data [$r = +.56$, $p < .001$], thereby providing an important source of external validation for the ratings made.

Consistent with previous work (Smallwood et al., 2003a, 2003b; see also Smallwood et al., 2004b) we excluded individuals high on dysphoria for the purpose of the examination of the interference between TUT and semantic information. Of the initial 30 participants, seven individuals with CES-D scores of 41 or higher were excluded from the analysis of the distribution of TUT as this value has been shown to predict subsequent depression (Radloff, 1977). To compare the distribution of TUT across the three conditions we conducted a repeated measures ANOVA. This ANOVA indicated an effect of condition on the frequency of TUT [$F(2,42) = 4.6$, $p < .01$]. Significant differences were observed between words and vigilance [$t(22) = 3.15$, $p = .005$] but not between non-words and vigilance [$t(22) = 1.5$, $p = .16$] or between non-words and words [$t(22) = -1.5$, $p = .13$].[6] Only encoding meaningful stimuli, therefore, reliably decreased the experience of TUT relative to the control vigilance condition.

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[6] The TUT reported by the seven dysphoric participants who were excluded from the analysis was distributed as follows: TUT Vigilance 0.40 (*SD* = 0.08), TUT Non-words = 0.17 (*SD* = 0.05) and TUT Words = 0.20 (*SD* = 0.04). A repeated measures ANOVA indicated a main effect of task [$F(2,10) = 4.70$, $p < .01$]. Post hoc *t* tests indicated significant differences between the experience of TUT between non-words and vigilance [$t(5) = 2.8$, $p = .03$] and approached significance for the contrast between vigilance and words [$t(5) = 2.4$, $p = .06$]. No difference was observed for the contrast between the words and non-words conditions [$t(6) = 1.00$, $p = .35$].

2.3.2. Stem completion and TUT

In total, 12 participants reported one or more examples of TUT in both the word and non-word conditions and are, therefore, included in the analysis for this section. Using the procedure detailed elsewhere (Smallwood et al., 2003b, Experiment 3), we averaged the number of words correctly reported for each task (words and non-words) for each block. These averages were then summated to reflect whether they were presented in a block in which TUT was reported or in a block in which task-focused thinking was reported (NTUT). These indices were subsequently compared using a repeated measures ANOVA which yielded three main findings. First, the ANOVA revealed two main effects: a main effect of task [Task: $F(1,11) = 32.2$, $p < .05$] suggesting that a higher number of stems were correctly completed in the word condition [*Mean* = 1.64 (*SD* = 0.18)] than in the non-word condition [*Mean* = .33 (*SD* = 0.12)]. Second, the ANOVA indicated a main effect of thought [Type of Thought: $F(1,11) = 4.74$, $p < .05$]. Finally, the ANOVA also revealed a Type × Thought interaction [$F(1,11) = 6.4$, $p < .05$, see Fig. 1]. This interaction was followed up by subtracting the number of word-fragments completed whilst experiencing TUT from the number of fragments completed without experiencing TUT. These indices were distributed as follows: Non-words *Mean* = 0.02 (*SD* = 0.59) and Words *Mean* = .41 (*SD* = 1.4).

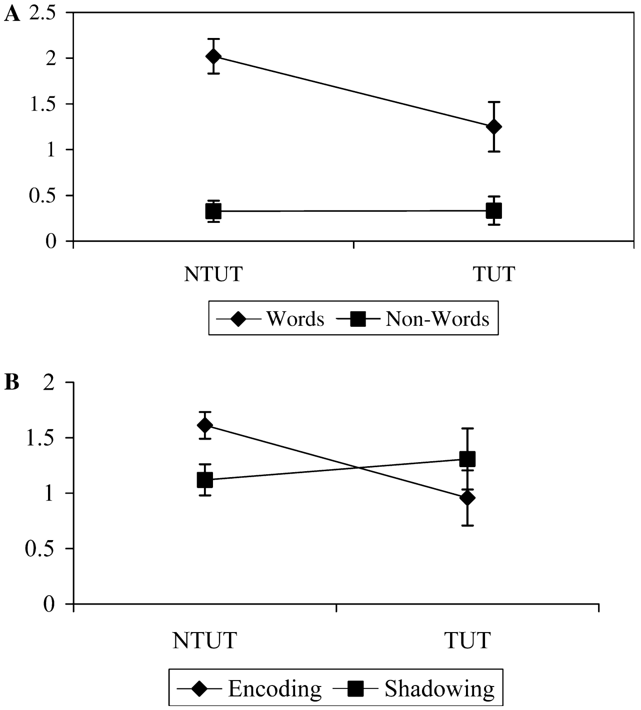

Fig. 1. The effects of experiencing TUT/NTUT on the subsequent retrieval of information. (A) The interaction between TUT during a block of stimuli (words and non-words) and the number of correct word-fragments (max 4) completed in the subsequent retrieval phase of Experiment 1. (B) The effects of experiencing TUT/NTUT during a block of verbal stimuli under different instructions (encoding and shadowing) and the number of correct word-fragments completed in the subsequent retrieval phase of Experiment 3.

Paired samples *t* tests indicated a reliable difference [$t(11) = -2.5$, $p = .026$][7] suggesting that participants showed a statistically greater advantage to retrieval following task-focused thinking relative to TUT during the words condition but not during the non-word condition.

2.3.3. Reaction time and TUT

The reaction time was averaged over the last 30 s for each block of each task. These blocks were then summated so that they reflected blocks in which TUT was reported and those that did not. This summation was conducted for each task (see Table 1). As in previous research using this technique (Smallwood et al., 2003b, Experiment 3), we included the individual's age as a covariate because age has been shown to moderate TUT (Grodsky & Giambra, 1989).[8] In total, 10 participants reported an instance of TUT in all three tasks and were included in this analysis. The ANCOVA indicated a Task × Type interaction [$F(2,16) = 4.13$, $p < .05$]. To follow-up this interaction, we subtracted the reaction time reported during TUT from the reaction time whilst experiencing task focused thinking (see Table 1). These indices were then compared using two further ANCOVAs which contrasted the effects of experiencing TUT on reaction time between: (i) non-words and vigilance and (ii) words and vigilance. In total, 14 individuals reported one or more examples of TUT in both the non-word and the vigilance task. The ANCOVA comparing non-words with vigilance indicated no significant effects ($p < .36$ for all comparisons). A total of 12 participants reported one or more TUTs in both the words and vigilance condition. These indices were compared using an ANCOVA again controlling for the participant's age [$F(1,10) = 4.8$, $p < .05$]. This analysis indicated that the increase in reaction time experienced during TUT was greater when encoding words than during vigilance.[9]

2.3.4. Dysphoria, current mood state, rumination and TUT

To explicitly examine the role that self-reported dysphoria, rumination and current mood levels play in the experience of TUT, we examined the association between the self-reported question-

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[7] For the sake of consistency with the analysis for the distribution of TUT, we repeated the analysis on number of word-fragments completed after excluding those individuals who reported CES-D scores of 41 or higher. Of the remaining eight participants the ANOVA indicated a comparable pattern of results: (i) A main effect of Task [$F(1,7) = 20.21$, $p < .001$], (ii) a main effect of thought [$F(1,7) = 8.5$, $p < .05$] and (iii) a Task × Thought interaction [$F(1,17) = 19.5$, $p < .001$]. The distribution of completed word-fragments was also similar: NTUT Words;= 2.12 (*SD* = .30), TUT Words = 1.0 (*SD* = . 25), NTUT Non-words = 0.23 (*SD* = .10) and TUT Non-words = 0.31 (*SD* = .16). For the sake of clarity we report on the analysis on the larger sample size in the body of the text.

[8] Analysis in which age was not included as a covariate indicated no main effects or any subsequent interactions (for all comparisons $p > .3$).

[9] As in the case of word-fragments we conducted secondary analysis on the non-dysphoric individuals. Unlike the analysis of completed word-fragments, when we excluded the dysphoric individuals the ANCOVA indicated that the task × type interaction was non-significant [$F(2,10) = 1.95$, $p = .19$], however an age × type of thought × task interaction approached significance [$F(2,10) = 3.1$, $p = .09$]. Bi-variate correlations indicated a trend implying age was reliably associated with higher reaction times during the word condition whilst experiencing TUT [$r = +.53$, $p = .08$] a finding which replicates the results of a previous experiment (Smallwood et al., 2003b, Experiment 3). Age was not reliably associated with any reaction time whilst experiencing task focused thinking [$r = -.25$, $p = .24$] or whilst experiencing TUT in the non-words condition [for all comparisons $p < .30$]. In the vigilance task, a trend was observed implying age was associated with faster reaction times whilst experiencing task related thinking [$r = -.36$, $p = .08$] but not associated with reaction time during TUT [$r = -.33$, $p > .30$]. The distinctive role that age plays in the experience of TUT across the different tasks is worthy of future research.

Table 2
The relationship between self-reported dysphoria, rumination, and thinking measured by both thought probes and the retrospective estimates of participants

	CESD		RSQ	
	Zero-order	Partial	Zero-order	Partial
Thought probes				
Vigilance	.38[*]	.40[*]	−.05	.15
Words	.05	.06	.25	.25
N/words	.02	.04	.03	.04
Retrospective self-report				
TUT	.33[*]	.20	.37[*]	.26
TRI	.13	.02	.02	.03

Partial correlations controlling for self-reported levels of rumination and dysphoria, respectively.
[*] $p < .05$.

naires and the distribution of TUT, both in terms of the verbal reports and the retrospective self-reported information (see Table 2). Consistent with previous research (Smallwood et al., 2004a, 2004b), whilst both rumination and dysphoria were associated with TUT, partial correlations indicated that only self-reported dysphoria was reliably associated with any measure of TUT. There was no reliable association between the distribution of any measure of TUT and any of the three measures of mood states (for all comparisons $p > .15$).[10]

2.4. Discussion of Experiment 1

The results of Experiment 1 can be summarised as follows. The distribution of TUT across the conditions implied that the strongest suppression of TUT was observed when encoding meaningful stimuli (see Table 1). Moreover, only when TUT was experienced whilst encoding meaningful stimuli was the experience of TUT associated with measurable differences in task performance (Table 1 and Fig. 1). In short, Experiment 1 provided evidence for the mutual inhibition between TUT and the co-ordination of semantic information. When encoding non-words, however, there was no statistical difference in the frequency of TUT relative to the baseline condition, or the consequences of TUT on concurrent task performance. This implies that there was no mutual inhibition between encoding non-words and TUT because: (i) their was no advantage to non-words following task focus and (ii) their were no consequences on reaction time whilst experiencing TUT and encoding non-words. Whilst the small sample size in some comparisons (i.e., $n = 10$) may imply that the conclusions are unreliable, there are reasons to suggest that these effects are robust. First, the effects of TUT on retrieval and reaction time parallel previous research (Smallwood et al., 2003b). Second, the conclusion that co-ordinating information in working memory is implicated in TUT can be easily reconciled with previous research (Smallwood et al., 2003a, 2003b; Teasdale et al., 1993, 1995). Overall, the small sample size notwithstanding, when the participants

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[10] It is worth noting that both energetic arousal and hedonic tone were positively associated with higher levels of correctly retrieved words during task focused thinking [Hedonic Tone: $r = +.38$, $p < .05$; Energetic Arousal: $r = +.41$, $p < .05$].

were asked to encode meaningful semantic information, participants were more likely to experience task relevant thinking, and, in terms of concurrent task performance (reaction time and number of items retrieved) benefited from doing so.

The results of Experiment One also support the role of personal salience in the generation of TUT. Consistent with previous research (Smallwood et al., 2004b; see also Seibert & Ellis, 1991), high levels of dysphoria were associated with high frequencies of TUT, measured by both respective questionnaire and the thought probes. With both dysphoria and sadness in general (Wiezbicka, 1972), the association between TUT and dysphoria is perhaps a consequence of the higher frequency of current concerns that are likely to be associated with dysphoria. It is worth noting that the verbal report of thoughts unrelated to the task was only associated with dysphoria in the vigilance task, a finding consistent with the results of a more detailed investigation (Smallwood et al., 2004a). It is possible that these findings have implications for: (i) the methods employed to reduce the experience of depressogenic thinking in a clinical setting and (ii) the situational determinants of daydreaming during vigilance. These issues are worthy of future research.

3. Experiment 2

3.1. Aims

The aim of Experiment 2 was to examine whether instructing participants to hold images in their head which are not personally salient yields: (i) a similar pattern of inhibition between external semantic stimuli and internal images and (ii) the same pattern of mutual inhibition between externally encoded information and internally maintained information. To this end, we employed the paradigm by Baddeley and Andrade (2000).

In their paper, Baddeley and Andrade (2000)[11] examined the influences on the vividness of images held in working memory, some of the images were based on information from short-term memory whilst others were derived from long-term stores. In addition, these authors manipulated the characteristics of the images along various dimensions such as dynamic/static images and whether the stimuli were bizarre or not. We opted to employ images that matched the hypothetical information processes involved in TUT as closely as possible. To achieve this aim, we used images from long-term memory, rather than those from short-term memory, given the importance of medium-term temporal issues, such as current concerns in the genesis of TUT (Klinger et al., 1980). Second, research has suggested that working memory suppression of TUT is largely targeted at sequential rather than fragmentary thoughts (Teasdale et al., 1993; Experiment 3A), suggesting that dynamic images are likely to reflect a more accurate analogue for TUT than static images. To investigate this issue, we included both static and dynamic images as an independent variable.

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[11] It may seem that images are an inappropriate analogue for TUT as they are likely to involve a large verbal component. However, research demonstrated that most TUT are in fact described by the participants as consisting of images (Teasdale et al., 1993, Experiment 3, see also Baddeley, 1993).

3.2. Methods

3.2.1. Participants

Twenty-eight participants were recruited from the University Psychology Department via advertisement. Of the 28 individuals, four were male and 24 were female. The mean age of the sample was 32.2 years ($SD = 16.1$), and on average, each individual had spent 16.5 years ($SD = 3.5$) in full time education. Ethical approval had been obtained from the University Psychology Department's ethics committee.

3.2.2. Materials

As in Experiment 1, we employed the words described by Jacoby (1998) as a source for the stimuli for the word condition. Unlike experiment one, the non-words were modified stimuli from the same stimulus set such as *slimp* (slump) or *roech* (roach). The Microsoft Word dictionary was employed to ensure that none of the non-words created represented English words. Of the 10 stimuli presented in each block, we selected three at random to act as critical items during retrieval. As in Experiment 1, we measured retrieval by word-stem completion. Of the stimuli for retrieval, 30 were words (15 each from the dynamic and static conditions) and 30 were non-words that were presented during the task. In addition, a further 15 stimuli of both types were presented as new items during the retrieval phase. As before, the word/non-word stimuli for retrieval were presented on a single sheet of paper in a random order.

The imagery stimuli used in Experiment 2 were the visual stimuli presented by Baddeley and Andrade (2000, Experiment 4). In total we used a selection of both the dynamic and the static images. We replaced several stimuli that described places in Cambridge with similar images from the Glasgow area. For example, we replaced "King's College Chapel" with "St. Enoch's Centre." In all 15 dynamic and 15 static images were employed.

3.2.3. Procedure

As in Experiment 1, all the stimuli were five letter alphanumeric strings presented in the centre of the screen. Regardless of task, all stimuli were presented in blocks of 10 sequential stimuli. Stimuli were presented on the screen for 2 s, with an inter-stimulus interval of two seconds. Overall, therefore, the total length of the maintenance of the image corresponded approximately to the last thirty seconds in Experiments 1 and 3. Each participant completed five blocks of each task before moving on to the next task. Order of blocks and tasks was fully counterbalanced. Unlike the previous experiment, participants were not instructed to push the space bar or make any overt movements.[12]

As in Experiment 1, all participants were tested individually across each task (control, word and non-word) and across each type of image (static and dynamic). At the outset of the experiment, participants were informed that they would be asked to maintain an image in their head whilst performing a variety of tasks. At the end of each block, participants would then be asked to rate the vividness of their image on a scale between 0 and 10, on which 0 corresponds to "no image at all" and 10 corresponds to "image as clear and vivid as normal vision." This scale was presented

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[12] We opted not to measure reaction time as a dependent measure in Experiment 2 because work by Baddeley and Andrade (2000, Experiments 1 & 2) indicated a reduction in the vividness of imagery whilst tapping.

on a sheet of paper and was visible to the participant throughout the duration of the experiment. An example of a static image was "St. Enoch's Centre" and an example of a dynamic image was "Terry Wogan tying his shoelace".[13]

3.2.3.1. Words and non-words. During the words and non-words conditions, participants were instructed to read each item silently and to try to remember the items for a later phase of the experiment.

3.2.3.2. Control. During the control condition five Xs were presented at the centre of the computer screen. Participants were asked to fixate upon these stimuli whilst concentrating on maintaining the image they were instructed to imagine.

3.2.3.3. Retrieval of information from memory. After completing all three tasks participants were asked to complete a paper and pencil word-stem completion task as a measure of retrieval. Participants were instructed to only complete the word stems with information presented in the encoding task as in Experiment 1. Participants were allowed five minutes to complete the word-stem completion task.

3.3. Results

3.3.1. Intensity of image

A 2 × 3 repeated measures ANOVA contrasted the effects of task (control, words and non-words) and type of image (static versus dynamic) on the subjective intensity of the image. The initial ANOVA indicated a main effect of task [$F(2,27) = 28.2$, $p < .001$] and a trend towards an effect of type of image [$F(1,27) = 3.4$, $p = .07$]. In a subsequent ANOVA, controlling for order effects (order of images, order of task and order of blocks), these effects were qualified as follows. First, the ANOVA yielded a reliable effect of type of image [$F(1,24) = 5.2$, $p < .05$] indicating that irrespective of task, static images [*Mean* = 5.9 (*SD* = .23)] were rated as less intense than dynamic images [*Mean* = 6.3 (*SD* = .31)]. Second, the ANOVA indicated a reliable effect of task [$F(2,24) = 21.96$, $p < .001$]. The mean intensity ratings for each task were as follows: Control: *Mean* = 7.4 (*SD* = .36), Words: *Mean* = 5.5 (*SD* = .36) and Non-words: *Mean* = 5.7 (*SD* = . 34). Post hoc paired *t* tests indicated that vividness was higher in the control task than whilst encoding either words [$t(27) = 6.1$, $p < .001$] or non-words [$t(27) = 5.31$, $p < .01$]. No difference was observed between vividness of image whilst encoding words and non-words [$t(27) = .87$, $p > .05$]. Finally a two-way interaction was observed [Task × Type, $F(2,24) = 3.6$, $p < .05$, see Fig. 2]. The two-way interaction was followed up by contrasting the effects of type of image separately across each task [Control condition: $F(1,27) = .433$, $p > .05$, Words: $F(1,27) = .537$, $p > .05$ and Non-words: $F(1,27) = 10.95$, $p < .01$] indicating that dynamic images were reliably more vivid than static images but this held only when encoding non-words. Given that dynamic images were only perceived as more vivid than static images in the non-word condition, the main effect of type of images reported above is a statistical artefact (see Fig. 2).

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[13] Baddeley and Andrade (2000) present the complete list of static and dynamic images employed in this study.

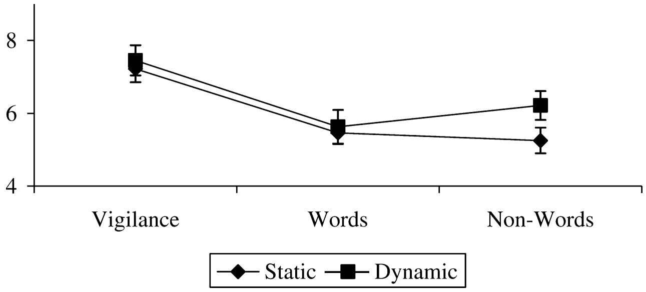

Fig. 2. Experiment 2. Vividness of image by task (control, words, and non-words) and type of image (static and dynamic). The *Y*-axis describes the vividness of the image.

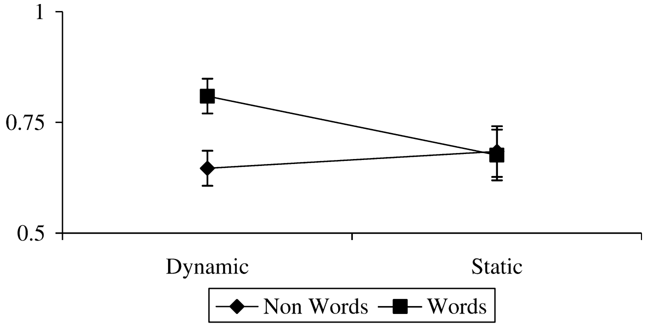

Fig. 3. Experiment 2. The accuracy of subsequent retrieval by task (words and non-words) and type of image (dynamic and static). The *Y*-axis describes the likelihood of completing a word-fragment correctly.

3.3.2. *Accuracy of retrieval*[14]

Likelihood of completing a word stem with erroneous information was as follows: Words *Mean* = .08 (*SD* = .08), Non-words *Mean* = .12 (*SD* = .10). This difference was unreliable [$t(21) = -1.2$, $p > .05$]. To compare accuracy of retrieval, we used a 2× 2 ANOVA with repeated measures on task (words versus non-words) and type of image (dynamic versus static, see Fig. 3).[15] This analysis indicated no significant differences, although a main effect of type approached significance [Type: $F(1,24) = 3.76$, $p = .06$, for all other comparisons $p > .1$]. However, separate ANOVAs on each type of image suggested a reliable effect of task only when processing dynamic images [Task: $F(1,24) = 6.57$, $p < .01$][16] indicating a higher recall for words when processing dynamic images [*Mean* = .81 (*SD* = .03)] than non-words [*Mean* = .65 (*SD* = 0.06)]. The ANOVA

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[14] Three individuals were excluded from the analysis of retrieval because they exhibited overall accuracy scores of less than 50%.

[15] Initial analysis using ANOVA indicated no effect of either task, type of image or the subsequent interaction on overall frequency of completed word stems [for all comparisons $p > .2$]. The overall distribution of completed word-fragments was as follows: Words dynamic 3.3 (*SD* = 0.41), Words static *Mean* = 3.7 (*SD* = .41), Non-words Dynamic: *Mean* = 3.6 (*SD* = . 46), Non-words static: *Mean* = 4.3 (*SD* = .53).

[16] For consistency with the analysis of intensity of images we repeated this analysis controlling for the counterbalancing. This secondary analysis still indicated a main effect of task [$F(1,12) = 5.22$, $p < .05$].

indicated no significant differences between the recall of words or non-words during the experience of static images [$p = .9$].

3.4. Discussion of Experiment 2

The results of Experiment 2 can be summarised as follows. First, regardless of type of image, encoding information, either words or non-words, yielded less vivid images than in the control condition. Thus, consistent with previous research (Baddeley & Andrade, 2000), co-ordinating information in working memory interfered with the vividness of an image. When the counterbalancing of the stimuli was controlled, however, this main effect was qualified by a task by image interaction which indicated that when the task was to encode non-words, dynamic images were experienced as subjectively more vivid. Stem completion showed a similar pattern with word stems showing an advantage over non-words when processing dynamic images only. As in the vividness of imagery, this association was unreliable and was not detected in the initial ANOVA.

A tentative account of this data is as follows. First, the co-ordination of information for subsequent retrieval reduced the subjective intensity of an image. However, whilst encoding meaningful stimuli (words) interfered with both dynamic and static images, encoding non-words only interfered with static images. This interpretation of the subjective information is supported by the accuracy of retrieval (Fig. 2): encoding words yielded an advantage over non-words when maintaining dynamic images. Therefore, similar to the distribution of TUT observed in Experiment 1, the intensity of dynamic images showed a pattern of mutual inhibition with the contrast between encoding words and non-words.

It is clear, however, that the mutual inhibition between the images maintained in the participant's awareness in Experiment 2 is less reliable than that interference observed between TUT in Experiment 1. Whilst it is possible that some of these differences are associated with superficial differences between the paradigms, it seems plausible that one component of the differences between the two paradigms employed in Experiments 1 and 2 reflects the hypothesised role of personal salience (Klinger, 1999). That is, whilst the images employed in Experiment 2 might monopolise similar resources in working memory, and share some phenomenal characteristics, such as a dynamic quality, they do not contain the personal salience that exemplifies TUT.

4. Experiment 3

4.1. Aims

The main aim of Experiment 3 was to assess whether the hypothetical personal significance of the information processed during the experience of TUT was observable in an objective physiological measure. Little is known about the physiological correlates of TUT, although previous research has identified an association between body temperature and TUT (Giambra, Rosenberg, Kasper, Yee, & Sack, 19881989). Similarly, physiological measures, including heart rate and Galvanic Skin Response (GSR) were depressed by the encoding of auditory stimuli (Antrobus, 1973). Although no measure of TUT was made in this particular study, the results of Antrobus (1973) are consistent with the recent claim that *"from a neuro-cognitive perspective this* (higher likelihood of TUT) *means providing more metabolic resources to frontal areas that are processing information at a rate above some hypothetical resting level"* (Antrobus, 1999, p. 21). On the basis of the assumption that TUT is involved in the processing of personally salient self-generated stimuli (Klinger, 1999) and mobilises physiological resources accordingly, we reasoned that there would be a positive association between physiological variables indicative of arousal and the experience of TUT. This association between TUT frequency and either measure of physiological arousal would indicate support for the position described by Antrobus (1999).

In addition, Experiment 3 aimed to address several limitations in the previous experiments in the present paper. First, whilst the comparison between words and non-words yielded the predicted differences in TUT (Experiment 1) and to a lesser extent vividness of dynamic images (Experiment 2), the nature of the comparison is problematic. In particular, it is plausible that the lack of effect of TUT on the retrieval of non-words, may represent a scaling problem associated with low levels of base-rate recognition when encoding non-words. Hence, in Experiment 1, memory for non-words may, in fact, have been too poor to show any further decrease due to TUT. Whilst this problem does not prevent conclusions regarding the semantic suppression of TUT frequency, nor of the consequences on reaction time, it is possible that the results of Experiment 1 on word-stem completion are an artefact of the experimental design.

A second problem concerning the comparison between word and non-words employed in Experiments 1 and 2, concerns the differences between the groups of stimuli in terms of alternative dimensions such as imageability. Thus, it is possible that whilst encoding words, but not non-words, spontaneous mental imagery resulting from the meaningful stimuli interrupted the experience of TUT in Experiment 1 and the vividness of the images in Experiment 2.

In some senses these differences are not relevant if one takes a holistic view of the influences on attention. It is hard to conceive of semantic stimuli which are less imageable than non-semantic stimuli, and moreover, one of the aims of Experiments 1 and 2 was to examine whether encoding stimuli rich in meaning and associations to the individual would interfere with the experience of internally generated images and thoughts. To select semantic stimuli which are low on imageability or some other stimulus dimension to control for these factors would not, therefore, reflect an ecological test of the hypothesis that spontaneous streams of thoughts and images are moderated by meaning complexes (Klinger, 1999). However, it is important to recognise that this comparison is problematic for the reasons cited above.

To account for these confounds, Experiment 3 examines the experience of TUT across two conditions, one in which the individual was required to *study* verbal stimuli, and the second in which the individual was instructed to *shadow*, but ignore verbal stimuli (see Smallwood et al., 2003b, Experiment 2, for a similar design). In this context, the semantic component of the stimuli in each task is held constant, and the appropriate counterbalancing, between individuals, can ensure that differences in stimulus properties such as imageability are held constant across conditions. If the experience of TUT makes a reliable contribution to encoding accuracy, using this design, we can be sure that it is not a consequence of crude scaling or fluency difficulties associated with the nature of stimuli processed in different conditions.

Finally, we made two minor methodological changes. Firstly, to minimise potential shortcomings, we attempted to ensure that TUT during the encoding condition was distributed across the individuals in the sample in a more consistent fashion. To achieve this aim, we extended: (i) the number of blocks of encoding and shadowing, from five blocks (Experiment 1 and 2) to eight and

(ii) the length of the blocks to between 120 and 140s. It was hoped that this would raise the base rate and ensure that as many individuals as possible reported an example of TUT during both study and shadow conditions. As a consequence of this design, however, practical limitations associated with testing duration prevented the inclusion of a vigilance condition as a control condition. Secondly, as a further methodological control, to ensure that the experience of TUT was not be moderated by an unknown property of the stimuli, we varied the source of verbal stimuli employed in this experiment from those employed in Experiments 1 and 2.

4.2. Method

4.2.1. Participants

A further 13 participants were recruited from a University Psychology Department, 3 of whom were male and 10 who were female. The mean age of the sample was 24.3 years of age (*SD* = 7.6). On average, each individual has spent 16.15 years (*SD* = 1.95) in full time education. The Psychology Department ethics committee had granted ethical approval for this study. As before, all participants were paid £10 at the end of the experimental session. Of the sample, two individuals did not report any examples of TUT and consequently they are only included in the correlational analysis (see below).

4.2.2. Materials

Stimuli for the study/shadowing task were selected from the ANEW word norms (Bradley & Lang, 1999). Approximately 250 stimuli were selected that were in the middle third of the distribution for each of the three affective dimensions presented in the list of norms. Examples of these stimuli included Quiet or Brave. These words were then randomly divided into 20 blocks of stimuli containing 12 ± 2 stimuli. The number of stimuli was varied in a quasi-random fashion, as an additional control, to ensure that participants could not anticipate the end of the block. Block order was fully counterbalanced.

4.2.3. Procedure

The procedure for Experiment 3 was identical to that employed in Experiment 1, with the following exceptions. First, five minutes before beginning the vigilance task the electrodes to record GSR and heart rate were fitted to each participant. The electrodes for recording GSR were always attached to the participant's non-dominant hand. Second, by way of counterbalancing, the study/shadow blocks were alternated. At the start of each study block, participants were instructed that their task was to read each word and attempt to remember as many words as possible. During the shadowing blocks, participants were instructed to read 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.

Stimuli presented under both study and shadow instructions were presented at a rate of one stimulus every five seconds with an inter stimulus interval of five seconds. Out of the stimuli presented during each block of study, four critical items were selected from each block at random. These critical items were transformed into word-fragments by removing 25% of the letters from each word at random. The stimulus presentation package used for this experiment was the Experimental Run Time Systems. Thought probes were employed in an identical manner to Experiment 1.

4.2.3.1. Galvanic skin response (GSR) and heart rate. All electrode attachment sites were cleaned with SkinPure (Nihon Kohden) prior to the attachment of electrodes. Ag–AgCl skin conductance electrodes (6 mm, Biopac Systems) were attached to the palm side of the medial phalanx of the index and middle fingers of the non-dominant hand. The electrodes were secured with Velcro straps. The electrolyte used was a commercially available preparation (KY Lubricating Gel, Johnson and Johnson) with a conductivity similar to that of the 0.051 M NaCl solution recommended for use by Fowles et al. (1981) and Golding (1992). The signal from the electrodes was amplified with a Biopac model GSR100 amplifier.

The ECG was recorded using a 3 lead setup. Three surface Ag–AgCl electrodes (8 mm, Biopac-Systems) were used, with one electrode placed on the palm side of the right and left wrists, and the third electrode placed on the anterior surface of the ankle ipsilateral to the dominant hand. The electrodes were secured with surgical tape (Blenderm, 3 M). The electrolyte used was Sigma Gel (Parker Laboratories). The signals from the electrodes were amplified with a Biopac model ECG100B amplifier, with a high-pass filter set at 1.0 Hz. The sampling rate for the ECG and the SCR channels was set at 500 Hz. Data acquisition and analysis were performed with Acknowledge software (Biopac Systems).

4.2.4. Retrieval phase

As in both previous experiments, retrieval was measured using a paper and pencil task, in this case word-fragment completion was used. During the retrieval phase, word-fragments were presented in a randomised list containing 80 items previously seen and 10 ‘new’ items. The instructions for word-fragment completion were identical to those employed in the first experiment.

4.2.5. Statistical analysis

In addition to the analysis of variance employed in Experiments 1 and 2, to examine the association between the physiological and behavioural variables recorded, we analysed the data in the form of bivariate correlations. The use of correlations was deemed appropriate because, unlike Experiments 1 and 2, we did not include a control vigilance condition, therefore making between-task differences less likely. Consistent with previous work, we employed non-parametric correlations (Smallwood et al., 2002, 2003a, 2003b).

4.3. Results

4.3.1. Distribution of TUT

Inter-rater agreement for Experiment 3 was 91%. The likelihood of a participant reporting TUT whilst under the two conditions (study/shadow) was as follows: Study: *Mean* = 0.18 (*SD* = .19) and Shadow: *Mean* = 0.24 (*SD* = .20). A paired samples t-test indicated that this difference was non-significant [$t(12) = .156$, $p > .05$].

4.3.2. Behavioural measures

4.3.2.1. Reaction time. Reaction time was calculated over the last 30 s of each block preceding the thought probe. Reaction time indices reflecting the type of experience (TUT/NTUT) and the two instruction conditions (Study/Shadowing) were calculated in the same manner as in Experiment 1 and were distributed as follows: (i) Study: NTUT *Mean* = 369 ms (*SD* = 111), (ii) Study: TUT

Table 3
Experiment 3. Relationship between the frequency of TUT and behavioural and physiological measures recorded during task completion

	Correlation with frequency of TUT		
	Encoding	Shadowing	Overall
Heart rate	.28	.75**	.58*
Galvanic skin response	.17	−.22	−.25
Reaction time	.35	.67*	.82**

* $p < .05$.
** $p < .01$.

Mean = 409 ms (*SD* = 140), (iii) Shadow: NTUT *Mean* = 205 ms (*SD* = 137), and (iv) Shadow: TUT *Mean* = 354 ms (*SD* = 156). Despite the means varying in the predicted manner, ANOVA indicated no effects of Instruction or Type of Thought on the distribution of reaction times [$p > .05$ for all comparisons]. Correlations, however, indicated that the frequency of TUT was positively associated: (i) across the entire task and (ii) specifically during the shadowing condition, but (iii) not under the instructions to study the information (see Table 3). This is broadly consistent with the notion that TUT monopolises awareness at the cost of exogenous attention.

4.3.2.2. Word-fragment completion. The distribution of word-fragments across the relevant conditions was calculated as described in Experiment 1. Likelihood of completing a word-fragment with false positive information was 0.15 (*SD* = .28). The distribution of completed word-fragments in Experiment 3 is presented in Fig. 1 (B). ANOVA indicated no significant main effects of type of thought or instruction. However, a Type of Experience × Instructions interaction [$F(1,9) = 5.0$, $p < .05$] was observed. This interaction was followed up conducting separate ANOVA on each type of experience (TUT/NTUT). ANOVA on the blocks in which task-focused thinking was reported yielded a reliable effect of instruction on the completion of word-fragments, with participants more likely to complete word-fragments when information was observed under the instructions to encode [$F(1,12) = 13.00$, $p < .01$]. By contrast, ANOVA on the completion of word-fragments during blocks in which TUT was reported yielded no significant differences [$F(1,9) = 1.34$, $p > .05$] indicating that during TUT the instruction to study information did not yield higher levels of word-fragment completion than the instruction to shadow information. This is consistent with previous research (Smallwood et al., 2003b, Experiment 2).

4.3.3. Psychophysiological measures

4.3.3.1. Heart rate. Average heart rate over the last thirty seconds of each block was calculated. The distribution of heart rate was then summated to reflect the influences of type of experience and task, as before. Mean heart rate was distributed as follows: (i) Study: NTUT [*Mean* = 75.7 BPM (*SD* = 7.3)], (ii) Shadowing: NTUT [*Mean* = 75.9 BPM (*SD* = 8.2)], (iii) Study: TUT [*Mean* = 77.5 (*SD* = 10.1)], and (iv) Shadowing: TUT [*Mean* = 77.6 (*SD* = 8.4)]. ANOVA indicated no reliable differences [for all comparisons $p > .05$]. By contrast, correlations between TUT and mean heart rate across the relevant conditions indicated that the frequency of TUT was positively associated with heart rate: (i) across the entire task and (ii) specifically during the shadowing condition, but (iii) not under the instructions to study the information (see Table 3).

This pattern of correlations parallels the relationship between reaction time reported above, and it provides: (i) important corroborative evidence that TUT reflects a state of arousal consistent with the hypothesised motivational component of this style of thinking and (ii) reflects an important source of validity for the construct of TUT because it varies with activity of the autonomic nervous system.

4.3.3.2. Galvanic skin response (GSR). Peak-to-peak increases in GSR over the last thirty seconds of each block were recorded and summated as for the three previous measures. Distribution of GSR was as follows: (i) Study: NTUT [*Mean* = 1.22 μmol (*SD* = .91)], (ii) Shadowing: NTUT [*Mean* = 1.19 μmol (*SD* = .61)], (iii) Study: TUT [*Mean* = 1.52 (*SD* = 1.1)], and (iv) Shadowing: TUT [*Mean* = 1.56 (*SD* = 1.6)]. ANOVA indicated no reliable effects [for all comparisons $p < .05$]. Moreover, unlike previous measures correlational analysis indicated no relationship between TUT frequency and increases in GSR (see Table 3).

4.4. Discussion of Experiment 3

The main aim of Experiment 3 was to investigate the association between TUT and physiological arousal as hypothesised by Antrobus (1999). It is clear that the positive association between heart rate and TUT supports the assertion that during the experience of TUT the body increases metabolism to reflect the processing of a hypothetically personally salient concern (Antrobus, 1999). This not only supports the assertion that daydreaming reflects the processing of thoughts with high personal salience, but provides an important source of validity for the investigation of the construct of TUT because the operation of the autonomic nervous system is to some extent outside conscious control. It is worth noting that the elevation in heart rate associated with TUT is unlikely to reflect an artefact of experimental fatigue because this is associated with lower heart rate (Lal & Craig, 2000; Riemersma, Sanders, Hildervanck, & Gaillard, 1977). At a methodological level, we replicated the mutual inhibition between experiencing TUT and the ability to derive semantic information from the external environment reported elsewhere (Smallwood et al., 2003b; see also Schooler et al., in press). The results of Experiment 3, therefore, provide an important source of heuristic support for the hypothesis that TUT monopolises working memory resources because it is influenced by both dimensions of meaning complexes: (i) the processing of semantic information and (ii) information of personal salience to the individual (Klinger, 1999).

5. General discussion

5.1. Methodological limitations

Before dealing with the implications of these experiments, it is worth dealing with several experimental limitations. First, it is clear that large differences can be seen between the two paradigms employed in this paper. These differences include methodological differences such as task length, stimulus presentation rate and the dependent measures themselves (frequency in Experiment 1 and vividness in Experiment 2). In addition, the results differ in terms of the consequences on performance (likelihood of retrieval in Experiment 1 and accuracy of retrieval in

Experiment 2). Whilst it is possible that some of these differences may, in fact, provide complementary information on the same phenomenon (for example, the intensity/frequency contrast), it is clear that some differences may actually reflect important differences between the paradigms. It is likely, for example, that the differences in stimulus presentation between the paradigms are a potential source of variance across experiments. This position is supported by evidence that faster presentation rates suppress TUT (e.g., Giambra, 1995) and are implicated in retrieval (see Jacoby, 1998 for a discussion of the paradoxical effects that stimulus presentation rates play on retrieval). In these experiments, we opted to keep the number of stimuli in the blocks constant across the experiments and we varied presentation rate. However, future research could vary stimulus presentation speed across these different paradigms to examine what differences, if any, this variable makes.

It is clear, therefore, that it would be overly simplistic to view the two paradigms presented in this paper as direct analogues of one another. Nonetheless, it is important to stress that the combination of the two paradigms allows us to make more accurate conclusions than we could on the basis of either experiment in isolation. In particular, there seems to be a reasonable degree of correspondence between the results of the three experiments presented in this paper in terms of the situational constraints for the experience of internally maintained images. For example, in the experiments presented in this paper and elsewhere (Baddeley & Andrade, 2000; Teasdale et al., 1993), both vividness of imagery and the frequency of TUT are reduced in tasks which require the co-ordination of task-relevant information in working memory. By contrast, the specific pattern of interference between semantic information on the images maintained in Experiment 2, on the one hand, with those experienced during TUT (Experiment 1 and 3), on the other was less consistent. This indicates that the personal salience of the information processed during TUT may play an important role in this interference associated with this phenomenon. From a methodological perspective, therefore, we recommend that in future, work on subjective experience should attempt to examine cross-paradigm consistency to provide results that are as free as possible from the particular demand characteristics of a given method.

One key experimental finding presented in this paper, that mutual inhibition occurs between TUT and the encoding of semantic information both in situations in which stimulus characteristics differ between conditions (Experiment 1) and in those when stimulus characteristics can be equated (Experiment 3) replicates previous results (Smallwood et al., 2002, 2003b). Whilst it still remains a possibility that differences in stimulus characteristics can account for the differences observed in Experiment 1, these stimulus driven differences are unlikely to account for the results observed in Experiment 3. Moreover, almost 85% of the sample in Experiment 3 reported an example of TUT whilst encoding information. This is in contrast to the lower percentage (approximately 50%) of the sample in Experiment 1. This elevation in base rate of TUT goes some way to confirm the generalisability of the phenomenon of TUT to the population at large. Finally, we replicated the suppression of encoding during TUT using an alternative stimulus set to that employed in either Experiment 1 and elsewhere (Smallwood et al., 2003b), thereby making it less likely that the phenomenon is a consequence of some hitherto unrecognised aspect of the stimulus set employed, such as imageability of the stimuli. Overall, on the basis of the evidence presented in this article, and in previous studies it seems clear that maintaining personally salient information in ones awareness interferes with the individual's ability to effortfully process semantic information from the external environment.

5.2. Phenomenological and information processing components of daydreaming

What can the results of these two experiments tell us about the phenomenology of our internal experience on a day-to-day basis? First, it seems plausible that the consistent with the assertion of Klinger (1999) the experience of internally generated thoughts and images requires the co-ordination of information in working memory which can be best described as semantic. As outlined in the introduction, previous research has demonstrated that when a task requires the co-ordination of information, performance suffers when the individual's attention strays from the task towards internal information (Schooler et al., in press; Smallwood et al., 2002, 2003b; Teasdale et al., 1995, Experiment 4). The work presented in this paper extends these findings in an important aspect. In all three experiments we demonstrated that only when encoding semantically rich information did the concurrent task take precedence over the internal streams of information. This interference can be seen: (i) in the phenomenological data (Table 1 and Fig. 2) and (ii) in the efficiency which the concurrent task was performed (Fig. 1A and B and 3). This specific pattern of interference implies that the semantic resources that are involved in the co-ordination of meaningful stimuli may, in fact, make concurrent demands on the resources required for the maintenance of internal streams of images and thoughts. FMRI evidence supports this claim, with studies demonstrating overlap between the conscious resting state and a semantic task, but no similarities between brain activity during conscious resting and a vigilance task (Binder et al., 1999). The implication of the association between the experience of TUT and semantic information in conscious awareness is a key assumption of the notion of meaning complexes (Klinger, 1999) and suggests that TUT "provides a system that allows reflection and planning to replace a more direct reactive mode of operation." (Baddeley, 1993, p. 26) and probably facilitates problem-solving in the less hazardous environment of the neural workspace (Cleeremans & Jiménez, 2002; Dehaene & Naccache, 2001).[17]

It is also plausible that the relationship between heart rate, reaction time and TUT reported in Experiment 3 is consistent with this perspective. It is clear that whilst the base rate of TUT frequency was not reliably effected by the instructions in Experiment 3, Table 3 indicates that only in the shadowing condition was their a close association between the three constructs: TUT, heart rate and reaction time. It seems plausible, therefore, that whilst the instruction to study information did not yield a statistically significant shift in frequency of TUT, it prevented the close coupling of the behavioural and physiological components associated with TUT, as was observed in the shadow condition. This interpretation should be considered speculative at present, however, it does illustrate the potential value of the detailed measurement of both behavioural and physiological indicators as a highly sensitive and objective tool to further our understanding of the phenom-

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[17] It is of course possible that the interference between TUT and external information processing occurs because the individuals working memory is monopolised with internally generated information, and whilst this information is not of a semantic nature, the monopolisation may prevent the co-ordination of working memory resources towards the derivation of semantic information from the external environment. This interpretation would account for the interference between TUT and external semantic processing demonstrated by the experimental work here and elsewhere (e.g. Schooler et al., in press). It is less clear if this interpretation would provide an adequate account for the FMRI data presented by Binder and colleagues (Binder et al., 1999).

enological and information processing components of daydreaming and ultimately conscious awareness.

Second, as we noted in the introduction, experience of TUT involves the processing of personally salient information (Klinger, 1999). Three lines of evidence presented in this paper suggest that the information processed during TUT is of personal salience, and that this salience is an important influence on exogenous attention. First, in Experiment 1, high frequencies of TUT were associated with high levels of dysphoria, a position consistent with previous research (Smallwood et al., 2004b). This is consonant with theoretical accounts of dysphoria which emphasises the importance of discrepancies between the current and ideal self (e.g., Pyszczynski & Greenberg, 1987). Hence, the association between TUT and dysphoria support the interpretation of daydreams as a state which is reflective of the individual's "unfinished business" (Singer, 1966). Second, it is clear that whilst some similarities can be seen between the results of Experiment 1 and 2, such as the relationship between the co-ordination of information in working memory and the frequency/vividness of internal information, the pattern of mutual inhibition in the second experiment was less reliable. Whilst the absence of evidence is not evidence of an absence, this finding is consistent with the notion that maintaining images in one's head which are familiar but not personally salient, elicits only moderate interference with exogenous attention (Klinger, 1999). By contrast, the verbal report of TUT has consistently been associated with impairments in the external attention both herein and elsewhere (Schooler et al., in press; Smallwood et al., 2002, 2003b). Finally, the association between heart rate and TUT presented in Experiment 3 has been recently replicated in a vigilance task (Smallwood et al., 2004a) and together these studies suggest that the likelihood of experiencing TUT is likely to be associated with personally salient information because the verbal reports correlate with higher levels of physiological arousal. Overall, the evidence presented in this paper supports the assertion that TUT is likely to be involved in the processing of personally salient information (Klinger, 1999; Singer, 1966) and that this personal salience is likely to be involved in the process whereby these thoughts monopolise working memory resources.

Finally, a tentative interpretation of the pattern of data presented in this paper is that images that are traditionally seen as less vivid (dynamic images, see Baddeley & Andrade, 2000) parallel the distribution of TUT. This is supported by the findings that: (i) dynamic images were more vivid during non-words than words and (ii) the effect of dynamic images on retrieval paralleled the distribution of TUT. Given that majority of examples of TUT, when engaged in no task, were described as sequential (Teasdale et al., 1993), it is tempting to suggest that TUT is, as was proposed at the outset of Experiment 2, similar in many respects to dynamic imagery. This position would be supported by the low frequency of TUT across a variety of tasks, implying that daydreams are easily disrupted by external stimulation (e.g. Smallwood et al., 2003a, 2003b, 2003c; Teasdale et al., 1993, 1995). Such an interpretation would certainly be plausible given the likely role that mental models of previous experiences play in conscious awareness, and the planning of future behaviour and presumably, therefore, in the experience of TUT (Johnson-Laird, 1988).

Whilst the interpretation of internal streams of information, the dynamic processing of personally salient information, is tempting one issue remains unclear—if static images are traditionally seen as more vivid—why were the dynamic images rated as more vivid than static images in the non-word condition (see Fig. 2)? There are likely to be several factors which influence this, including methodological issues, such as the use of a concurrent task with semantic stimuli. One possibility, however, is that whilst generally static images are reported to be more vivid, they differ on how the information is updated in working memory: static images can be "gradually built up over time ... becoming richer as the retention period progresses. However an image of a dynamic scene requires a representation which loses as well as gains information over time" (Baddeley & Andrade, 2000). It may be the case that the effort on behalf of the participant to 'refresh' dynamic images monopolises the processing capacity that would otherwise be directed towards the encoding of non-words. This position is tenable, particularly given the larger, effortful requirement for the encoding of non-words, and implies that the more vivid dynamic images were in fact a consequence of a criterion shift towards imagery over non-words in the dynamic condition. At first glance, this interpretation may shed doubt on the validity of the second experiment, however, two reasons can be suggested why this is not the case. First, the consequences of co-ordinating information in working memory reliably reduced the vividness of the images in working memory (Fig. 2), in a manner, which is consistent with previous work (Baddeley & Andrade, 2000). Moreover, the distribution of images in Experiment 2, does in fact closely mirror the findings of work on TUT (Teasdale et al., 1993 Experiment 3A). In Teasdale's experiment, participants were required to maintain a series of digits in working memory and to recall the most recent digit when probed to do so at random intervals. Analysis indicated that the individual's awareness of the numerical digits co-varied with the experience of TUT such that high awareness of the digits was associated with low levels of TUT. Similar results were observed under conditions of random number generation (Teasdale et al., 1995, Experiment 4). The dynamic advantage during the encoding of non-words could plausibly be an example of a similar phenomenon. Dynamic images were only reliably more vivid than static images when the individual was asked to encode non-words. Similarily, it is under these conditions that non-word recall was least accurate. Thus a tentative account of the data in Experiment 2 might suggest that vividness of dynamic images was at the cost of awareness of non-words during encoding, in a manner that is similar to the relationship between TUT and awareness of stimuli (Teasdale et al., 1993, 1995). Importantly this issue is open to experimental testing: if TUT does share an important similarity with dynamic imagery, those TUT which form "larger connected sequences" (Teasdale et al., 1993) should be the examples of TUT which show the greatest interfere with concurrent task performance. Future research should examine this issue in detail.

The research presented in this paper, in conjunction with previous research, provides reliable evidence that is broadly consistent with the assertion that the processing of information in the form of a daydream is influenced by *meaning complexes* (Klinger, 1999). First, the likelihood of experiencing a daydream varies with the semantic content of the stimulus environment (Experiment 1) and also shows a pattern of mutual inhibition, such that experiencing examples of TUT are associated with less accurate recall of semantic information (Experiments 1 and 3). Second, the personally salient aspects of these thoughts appear to play an important role in the monopolisation of attention. This perspective is supported by three lines of evidence: (i) high levels of dysphoria have been consistently associated with high levels of TUT (Experiment 1), (ii) the mutual inhibition between semantic information and internal images is more consistent in the TUT paradigm (Experiments 1 and 3) than when the participants were asked to maintain images in their awareness that were familiar but not personally salient (Experiment 2), and (iii) consistent with the assertion of Antrobus (1999) the frequency of TUT was associated with higher levels of physiological arousal as measured by heart rate (Experiment 3).

6. Speculative conclusions

It is worth noting the implications that these results have for our understanding of the mechanisms that contribute to conscious awareness. Whilst not directly measured in either experiment, the effort directed towards task completion is likely to be larger when encoding non-words for subsequent retrieval. However, in the non-word condition of Experiment 1 there was no advantage to the individual by concentrating on the task, either in terms of reaction time or the number of words correctly retrieved. In contrast, when encoding words, the experience of task-focused thinking was associated with faster reaction times and higher levels of stimulus retrieval. This implies that the semantic stimulus contains information that enhances an individual's ability to attend to the task. When encoding semantic information: "The overall result [of conscious awareness] is greater alertness, sharper focus, higher quality of image" (Damasio, 2000, p. 183). Such a position is consistent with the verbal reports of the participants and the data on the subsequent retrieval of semantic information both in Experiments 1 and 3 and elsewhere (Smallwood et al., 2002; Smallwood et al., 2003b, Experiment 3). A similar explanation can be suggested for the effects of semantic categories (Smallwood et al., 2003a, Experiments 1–3; Smallwood et al., 2003b Experiments 1 & 2). Evidence suggests that a categorical stimulus organisation was associated with higher recall and fewer examples of TUT than a random stimulus organisation. However, when the participants were instructed to shadow the relevant stimulus material, there was no difference across conditions either in verbal reports or the data retrieved from memory (Smallwood et al., 2003b, Experiment 2). The effects of categories on task focus were, therefore, contingent on task engagement and this implies that, similar to the effects of semantic information presented in this paper, the effects of categories impact upon our phenomenological experience by offering the participant a quality of information in the external environment that they benefit from attending to.

It seems plausible that higher order influences on attention, such as the beneficial effects of semantic information (Experiments 1 and 3) or categorical information (Smallwood et al., 2003a, 2003b), are neither a property of the stimulus, or of the task in isolation but a combination of both. In these cases, it may not make sense to talk about the consequences of the quantity of resources directed towards task completion as a determinant of subjective experience. Rather, it appears to be the case that some types of task present the individual with the opportunity to maintain their attention with greater efficiency (Experiment 1 and 2 in this paper, Smallwood et al., 2003a, 2003b) or for longer durations (Smallwood et al., 2003c; see also Szalma et al., in press, for a complementary view on subjective experience during a vigilance task) than do others. Similarly, investigations of the distribution of subjective experience during reading indicate interest, but not difficulty, was associated with the frequency of TUT; dull texts produced significantly higher numbers of TUT than interesting texts (Grodsky & Giambra, 1990). In contrast, TUT during vigilance was lower when the task was difficult (Grodsky & Giambra, 1989). Whilst resource allocation may, therefore, offer a potential explanation for the role of low level features such as presentation pace or memory load on subjective experience, the influence of higher order features on the experience of TUT, such as interest or the semantic qualities of the information processed, may be more appropriately described as an *affordance.*[18]

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[18] Micheals and Carello (1981) suggest that two important aspect of affordances are that they are: (i) for acting on (page 47) and (ii) they reflect biological limits to learning. This idea was initially proposed by Smallwood (2002).

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