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Conscious intrusion of threat information via unconscious priming in anxiety

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Preferential processing of threat has been implicated in the development and perpetuation of anxiety. We investigated threat processing and anxiety using a subliminal priming paradigm. People with high or low trait anxiety viewed masked, briefly presented words, and then took an exclusion-completion test in which three-letter stems were to be completed without using recently perceived words. Completion rates were greater for words viewed subliminally compared to a baseline estimate. In addition, unconscious priming was greater for threat than for neutral words in the high-trait-anxiety group, and for neutral than for threat words in the low-trait-anxiety group. Enhanced unconscious priming of threat completions among anxious individuals may model intrusions in anxiety, when unconscious processing breaks into consciousness in the form of threat-related intrusive thoughts.

Research from behavioural, psychophysiological, and neuroimaging perspectives has suggested that preferential processing of threat can be automatic or even unconscious, and that it is more salient among anxious than non-anxious individuals (Davidson, 1998; Dolan, 2002; Lang, Bradley, & Cuthbert, 1998; Williams, Watts, MacLeod, & Mathews, 1997). In this area of research, however, the association between conscious and unconscious threat processing remains unclear. In the current study we investigated how *unconscious* threat processing broke through into *conscious* processing. Towards this end, we used a priming paradigm that severely limited conscious perception of briefly presented words, and we included rigorous

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monitoring to assure that the meanings of these words, were only processed subliminally.

Automatic processing of threat information may have critical implications for the development and maintenance of anxiety (McNally, 1995; Williams et al., 1997). Panic attacks, obsessions, worries, and so forth, can seem to occur involuntarily. While there are multiple types of automatic processing (Bargh, 1989; McNally, 1995), unconscious processing of threat is a type of automatic processing that is especially relevant to the core symptoms of pathological anxiety. Unconscious processing of threat may contribute to the experience of what is perceived as free-floating anxiety in generalised anxiety disorder (Mathews & MacLeod, 1986), and may be responsible for panic attacks that occur without awareness of threat. An anxiety patient, for instance, may experience a spontaneous panic attack following the unconscious processing of certain bodily sensations such as a palpitation (Clark, 1988). Empirical studies using methods such as subliminal emotional Stroop (e.g., MacLeod & Hagan, 1992; Mogg, Bradley, Williams, & Mathews, 1993) and subliminal dot probe tasks (e.g., Luecken, Tartaro, & Appelhans, 2004) have now provided evidence that supports this notion of enhanced unconscious threat processing in anxiety (see Mathews & MacLeod, 2005; Williams et al., 1997, for reviews).

Intrusive thoughts may also arise due to unconscious signals of threat, which could emerge in the form of excessive worries and obsessions, as well as a general perception of uncontrollable anxiety, part of the core phenomenology of anxiety disorders (Borkovec, Shadick, & Hopkins, 1991; Craske, Rapee, Jackel, & Barlow, 1989). A key question thus becomes whether unconscious threat processing may break into conscious awareness and lead to anxious intrusions. Previous studies using divided attention (e.g., dichotic listening) suggested that threat words in the unattended channel could "intrude" into conscious awareness and be reported (e.g., Burgess, Jones, Robertson, Radcliffe, & Emerson, 1981; Foa & McNally, 1986). However, such a phenomenon may not truly reflect unconscious threat processing. In a divided attention paradigm, the possibility of a momentary attentional shift to the unattended channel (Holender, 1986; McNally, 1995) implies that threat processing may not be unconscious in these circumstances (Nielson & Sarason, 1981). Indeed, this intrusion effect could be eliminated if momentary attentional shifts to the unattended channel were strictly inhibited (Trandel & McNally, 1987).

To examine whether unconsciously perceived threat information can insidiously influence conscious experience, we used subliminal priming methods with backward-masked primes (Balota, 1983; Marcel, 1983). Subliminal priming can provide a useful way of investigating unconscious processing, in that performance can be systematically altered as a result of prior experience (Schacter, 1987). In particular, a large literature on

subliminal affective priming has shown that unconscious information can modify conscious behaviour in an affect-consistent manner (see Fazio, 2001, for a review). However, investigations of this effect in the context of individual differences in self-reported anxiety are uncommon. A few priming studies that did take anxiety into account did not address the issue of conscious intrusions in anxiety (Bradley, Mogg, & Williams, 1994; Dannlowski et al., 2006; Hermans, Spruyt, De Houwer, & Eelen, 2003).

Thus, in the current investigation we applied a novel paradigm that allowed for a direct assessment of whether subliminally presented information breaks into conscious experience as a tentative model of anxious intrusion. We used a stem-completion task in which participants were asked to complete three-letter stems with the first word to come to mind. Each stem corresponded to a word previously presented subliminally. Half of these were threat words and half were neutral words. Importantly, participants were instructed not to give as a completion any word presented prior to the mask.

Prior studies of threat-relevant priming in anxiety were recently reviewed by Coles and Heimberg (2002). Forty percent of these studies found significantly greater priming to threat than neutral information as a function of anxiety. For example, patients with panic disorder, but not healthy controls, produced more completions with studied threat than neutral words (Cloitre, Shear, Cancienne, & Zeitlin, 1994). However, these studies did not concern stimuli processed without conscious awareness, and so the results are not directly relevant to the question posed here.

A stem-completion test with subliminal presentation and exclusion instructions similar to that in the present study was used independently by Wikström, Lundh, and Westerlund (2003). However, their results failed to demonstrate significant priming for subliminal words or a significant influence of word valence and trait anxiety on priming. Importantly, each word was presented only once. Perhaps a single subliminal word presentation is insufficient to yield reliable priming (Kamiya, Tajika, & Takahashi, 1994). Subliminal words presented ten times did yield significant priming in a task requiring speeded categorisation of words as fruits or vegetables (Beauregard, Benhamou, Laurent, & Chertkow, 1999). One other notable aspect of the Wikström study was that presentation duration was based on visual threshold assessed only at the beginning of the experiment, and so it is possible that some words were visible later in the experiment, resulting in exclusion of these words and reduced priming overall. Although designed prior to the publication of the Wikström results, our paradigm differed in two potentially critical ways. First, we presented the same set of subliminal words multiple times in an emotional Stroop task a few minutes prior to the stem-completion test. Second, we assessed awareness of the brief word presentations after the emotional Stroop task was completed, which was

immediately prior to the stem-completion test, and we excluded data from seven participants for whom word identification was supraliminal. The dividing line between word awareness and unawareness can have different meanings depending on how awareness is assessed. In the present experiment we use the terms subliminal and unconscious to refer to word processing when (1) words were presented below the perceptual threshold for identification measured for each participant; and (2) participants denied seeing these words throughout the experiment based on trial-by-trial assessments.

To summarise, we investigated the extent to which unconscious processing influenced stem-completion priming, thus indicating that the primed information was consciously experienced. Priming in this paradigm is substantiated by an increment in completion above baseline rates and is expected for both threat and neutral words, even though participants are told to exclude those words. We tested healthy participants who were categorised as high or low in their general proneness to anxiety. Given the assumption that trait anxiety (TA) can impact threat processing (Mathews & MacLeod, 1994; Williams et al., 1997), we predicted a bias to threat in subliminal priming that would be greater in high-TA participants than in low-TA participants. We reasoned that increased production of threat words as a result of unconscious threat priming could shed light on some of the underlying mechanisms responsible for the experience of anxiety as a function of unconscious processing of threat.

METHOD

Participants

Right-handed native English speakers were selected from 160 college students based on scores on the Behaviour Inhibition Scale (BIS; Carver & White, 1994), which is described in detail below. The sample consisted of 40 students (57% female, age range 17–24), including 19 students with the highest scores (top 12%, BIS scores ranged from 23 to 28) and 21 students with the lowest scores (bottom 13%, BIS scores ranged from 7 to 16). Participants gave informed consent and received class credit.

The BIS was completed again 5–8 weeks after the initial assessment (at the beginning of the experiment). Scores from the two assessments were averaged, so that state anxiety and other sources of measurement error (vis-à-vis trait anxiety) would tend to be averaged out, yielding a better measure of trait anxiety (see details below). We also analysed data using only the second BIS scores and obtained findings compatible with those reported (available upon request).

As part of the procedure, described below, we obtained a report on each participant's conscious awareness of each subliminal word. During this awareness check, three high- and four low-TA participants identified one or more words, who were then excluded from analysis. Awareness of stimuli and BIS scores were not significantly correlated, $r = .12$, $p > .05$. Two other participants did not complete the stem-completion task due to lack of time. Ultimately, 15 participants formed the high-TA group and 16 the low-TA group. BIS scores in the high-TA group ranged from 17.5 to 26.0 ($M = 22.9$, $SD = 2.1$), and in the low-TA group ranged from 8.5 to 15.5 ($M = 12.8$, $SD = 2.0$), $t = 13.71$, $p < .001$.

Behavioural Inhibition Scale

The BIS consists of seven items (e.g., "I worry about making mistakes"; "Criticism or scolding hurts quite a bit") rated on a 4-point scale ranging from *very little* (1) to *very much* (4). The BIS has adequate reliability, with estimates of .74 for the alpha coefficient and .66 for the eight-week test–retest reliability (Carver & White, 1994). Here, these indices also indicated satisfactory reliability; alpha coefficients for first and second assessments were .83 and .85, and test–retest reliability between the two assessments was .80, $p < .001$.

The choice of BIS as the measure of TA in this study stemmed from assertions made by Carver and White (1994) and Fowles (1987) that, when measuring TA, one should consider the distinction between sensitivity of the anxiety system and a person's typical or average anxiety level. They note that scales such as the State–Trait Anxiety Inventory (STAI; Spielberger, 1983) and the Manifest Anxiety Scale (MAS; Taylor, 1953) tap average anxiety level (e.g., "I feel calm"; "I am jittery") and argued that they might thus be problematic. For instance, people with high anxiety vulnerability may learn to avoid anxiety-provoking situations more readily than others and consequently experience relatively little anxiety on a daily basis. The BIS was designed to assess anxious responses to threatening situations instead of general affective tone.

Indeed, the BIS has been shown to have stronger predictive validity for changes in anxiety in the face of physical and social threat while being moderately correlated with the STAI and the MAS, with *r*s ranging from .45 to .58 (Carver & White, 1994; Zinbarg & Mohlman, 1998). Among large samples of psychiatric patients ($N > 1800$), convergent and discriminant validity of the BIS as a measure of trait anxiety was demonstrated by data showing that BIS was correlated most strongly with measures of neighbouring personality constructs (e.g., neuroticism) as opposed to measures of concurrent anxiety (Campbell-Sills, Liverant, & Brown, 2004; Johnson, Turner, & Iwata, 2003). Most pertinent to the purpose of the current study,

the BIS was predictive of enhanced processing of negative information, as assessed by affective ratings of positive, negative, and neutral words, and by free recall of those words, with equivalent or greater validity in comparison to the STAI (Gomez & Gomez, 2002). The BIS was also predictive of the formation of aversive expectancies to threat cues with greater validity than the STAI (Zinbarg & Mohlman, 1998).

Stimuli

Neutral words (190) and threat words (160) were collected from several sources (Bradley & Mathews, 1983; Mathews, Mogg, May, & Eysenck, 1989; http://www.psy.uwa.edu.au/user/labs/cogemo/atrain.htm). Twelve different undergraduates rated the affective valence of these words on a scale of 1 (*extremely negative*) to 9 (*extremely positive*). The mean valence rating was 5.09 for the 48 selected neutral words and 2.72 for the 48 selected threat words (valence ratings were not acquired from the experiment participants). Words contained five to ten letters (threat and neutral words were matched for length at 6.73 and 6.79 letters, respectively). Threat and neutral word frequencies (Johansson & Hofland, 1989) were also matched (means were 21.78 and 24.00 occurrences per million, respectively). Each of the 96 words had a unique stem that could be completed by at least one alternative word with a higher frequency than the test word. These words were divided into three 32-word sets, each with an equal number of threat and neutral words (as listed in the Appendix). The sets were matched for word frequency, word length, and affective valence.

Procedure

Each participant sat in a dimly lit, sound-attenuated chamber facing a CRT monitor 140 centimetres away. The experimenter and the participant communicated over an intercom. Words were presented on the monitor and subtended an average horizontal visual angle of 1.4 degrees. The mask, #&&###&&,[1] was presented with a horizontal visual angle of 2.2 degrees. In the emotional Stroop task and awareness check, one word set was presented subliminally, one supraliminally, and the third not presented so corresponding stems could be used to assess baseline completion. Subliminal, supraliminal, and baseline trials were presented in a random order. Assignment of word set to condition (subliminal, supraliminal or baseline) was counterbalanced across subjects.

[1] This type of mask may not provide maximal restrictions on conscious processing, but it was effective in most participants in the present study, and was comparable to those used in related studies (Beauregard et al., 1999; Wikström et al., 2003). Whether a different type of mask would produce the same patterns of unconscious priming is unknown.

Perceptual threshold determination

First, each individual's perceptual threshold was assessed to determine the exposure duration for subliminal trials in subsequent tasks. Each word was presented very briefly and rapidly replaced by a mask of symbols (#&&###&&). These words included six threat words (*hatred*, *scare*, *bleed*, *ashamed*, *hazard*, *conflict*) and six neutral words (*variable*, *fetch*, *radar*, *enlarge*, *marble*, *ballot*), and were not used again in the experiment. Participants were instructed to identify the presented word on every trial, and if they did not know the word they were required to guess. A word was first presented for 8.3 ms and replaced by the mask for 410 ms, followed by a fixation cross for 2500 ms. If the participant was unable to report the correct word at this exposure duration, it was presented again at an SOA (stimulus onset asynchrony) of 16.6 ms, and if he or she could still not identify the word, the SOA was increased to 25.0 ms, and so forth, with exposure duration increasing in steps of 8.3 ms, until the word was identified. This procedure was repeated for each word.

The perceptual threshold was defined as the lowest threshold (shortest SOA) among the thresholds for the 12 words. The average threshold across all participants was 46.5 ms ($SD = 10.9$). Threshold did not vary reliably with TA status ($F < 1$, $p > .1$). To restrict conscious awareness, a below-threshold SOA was selected for subliminal trials as follows: (a) 25 ms for participants with a threshold from 33.3–41.7 ms (none were lower), or (b) 30 ms for participants with a threshold above 41.7 ms. Two screen refresh rates, 100 Hz and 120 Hz, were used to allow for these SOAs. Among the final group of 31 participants, SOA was set to 25 ms for 14 (6 high- and 8 low-TA participants), and to 30 ms for 17 (9 high- and 8 low-TA participants). We note the SOAs here were longer than those used in some previous studies (e.g., 14 ms or 17 ms), in part because we determined the SOAs based on visual thresholds via verbal report of word identification (Marcel, 1983), rather than choosing some arbitrary SOAs and later validating unawareness on measures like lexical decision accuracy (Williams et al., 1997).

Finally, we obtained a threshold pooled across the 6 threat words and one across 6 neutral words for each subject and submitted them into a repeated measures ANOVA, Word Type (threat vs. neutral) × Group (low vs. high TA). We found these thresholds did not vary reliably with affective valence, TA group, or the interaction between the two (Fs < 1, ps $> .1$). Of course, power of these analyses could be attenuated by the small sample sizes, which might contribute to null effects.

Emotional Stroop task

This task served to provide exposure to sets of threat and neutral words (these words were critical words in the subsequent stem-completion task, described below). In addition, data were acquired for another study (Li, Zinbarg, & Paller, in press), which required three conditions: subliminal, supraliminal, and symbol. Words in subliminal and supraliminal conditions were presented six or seven times each in one of three colours (yellow, blue, or green). In the subliminal condition, a word was presented briefly followed 25 or 30 ms later by the mask in the same colour for 408.3 or 410 ms (this number is rounded to 410 henceforth). This 25- or 30-ms SOA included two refresh cycles of word presentation and one refresh cycle of a fixation cross alone (Figure 1). In the supraliminal condition, a coloured word appeared for 410 ms. In the "symbol" condition, a coloured mask appeared for 410 ms. On each trial, participants made a speeded three-choice discrimination response to indicate stimulus colour. Brain electric potentials during the emotional Stroop task were recorded, and analyses of these findings are reported in another paper (Li et al., in press).

Stem-completion task with awareness check

In this phase of the experiment, awareness of words was assessed and priming was measured, using the same 32 subliminal and 32 supraliminal words that were presented previously. Trial-by-trial assessment of awareness of words was important because thresholds may have changed due to adaptation and word repetition during the emotional Stroop task.

Three types of trials, subliminal, supraliminal, and baseline, were administrated as illustrated in Figure 1. Each trial began with a word and/or a mask using the same timing, word lists, colours, and font parameters as in the emotional Stroop task. Following the question ("What's the word?"), participants either attempted to report the word or said "no". They were strongly encouraged to guess even if they had a very unclear perception of the word. Absence of conscious awareness was operationally defined as failure to report any masked words. If a participant ever correctly reported a word in the subliminal condition (as happened for seven subjects), data from all trials were excluded. Words given with an added suffix of *-s*, *-ed*, or *-ing* were counted as correct (e.g., feathers, wounded, suffering). The same criterion also applied to scoring stem completions.[2]

A matching three-letter stem in the same font and colour as the corresponding word was presented following each awareness check. In baseline trials, the stem matched a word from the otherwise unused set.

[2] We also analysed stem-completion data without counting inflected forms as completions, and results were essentially identical. Results of the re-analysis are available upon request.

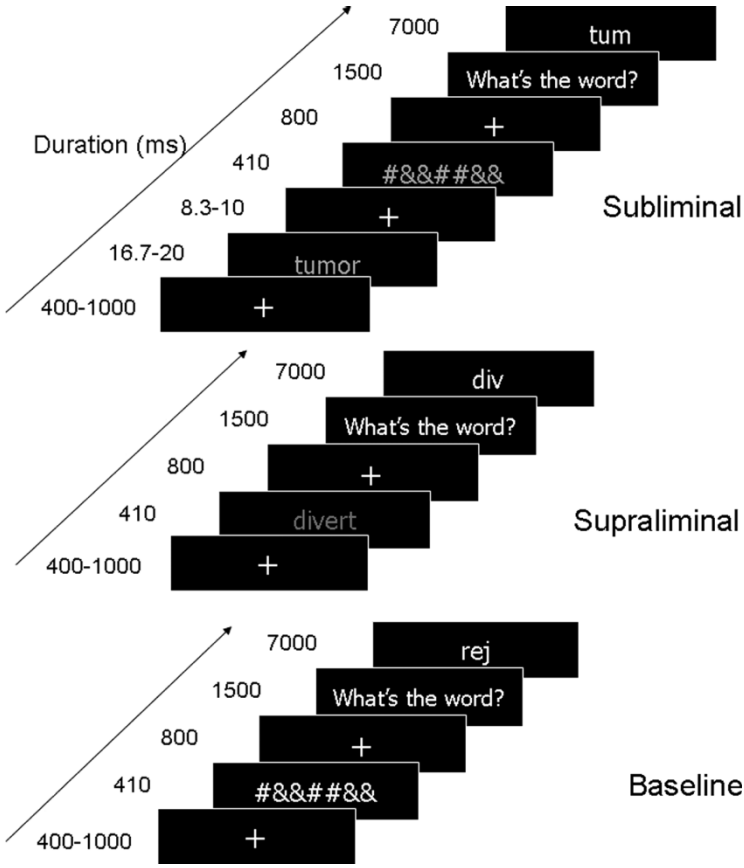

Figure 1. Experimental procedure for the stem-completion task. Examples of subliminal, supraliminal, and baseline conditions with words "tumour," "divert," and "reject" as critical completions, respectively.

Participants were instructed to complete the stem to the first word to come to mind by adding at least two letters while excluding any word just seen. Given the possibility that the stem led to conscious awareness of the word, the instruction to exclude the word when producing a completion provided a further safeguard against contamination by conscious perception of a word.

RESULTS

The logic for this study is based on the assumption that subliminal word perception can elicit unconscious processing and result in an increased likelihood of using that word in the stem-completion task. Thus, we first

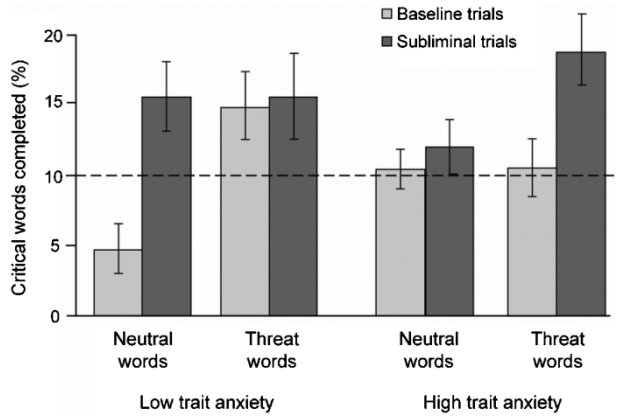

Figure 2. Completion rates (percentage of critical words produced) in the stem-completion task for subliminal words (dark bars) and baseline words (light bars). Dashed line shows average baseline completion rate. Unconscious priming is indexed by a significant increase in completion rate for subliminal versus baseline conditions. Error bars denote standard error of the mean within each condition.

examined whether there was an overall priming effect for subliminal words. Unconscious processing was confirmed by a significant priming effect in the form of higher completion rates for subliminal words compared to baseline words, when collapsed across word valence and TA groups, $t(30) = 2.51$, $p = .02$. The mean completion rates were 13.2% ($SD = 8.9\%$) and 7.4% (6.8%) for baseline threat and neutral words, respectively, and 17.1% (10.9%) and 13.9% (8.8%) for subliminal threat and neutral words, respectively.

We then tested the hypothesised interaction between TA and word valence on priming. Figure 2 summarises completion rates for threat and neutral words in subliminal and baseline conditions for high- and low-TA groups. Priming difference scores were computed by subtracting completion rates for baseline words from completion rates for subliminal words. A two-way ANOVA showed that word valence and TA group interactively influenced these difference scores, $F(1, 29) = 10.18$, $p = .001$, whereas neither factor independently affected difference scores ($ps > .1$).[3] In the high-TA group, priming difference scores were significantly greater for threat than for neutral words, $t(14) = 2.28$, $p = .04$. In the low-TA group, in contrast, priming difference scores were significantly greater for neutral than for threat words, $t(15) = 2.38$, $p = .03$.

[3] We also analysed trait anxiety as a continuous variable. Consistent with ANOVA results, unconscious threat processing (threat-minus-neutral priming score) was positively correlated with trait anxiety ($r = .47$, $p < .01$).

An interaction between word valence and TA was also observed on baseline completion rates, $F(1, 29) = 7.87$, $p = .009$. This interaction resulted from greater baseline completion rates for threat words than neutral words, $t(15) = 4.62$, $p = .0003$, in the low-TA group, whereas baseline completion rates were virtually identical for threat words and neutral words in the high-TA group, $t(14) = .00$.

Because data from seven participants were excluded based on the awareness-check procedure, counterbalancing for word sets was no longer even in the final sample. However, assignment of word set to condition did not affect priming either independently or interactively with word valence and TA ($ps > .1$), and results remained essentially identical with word set used as a covariate.

The supraliminal condition provided evidence that participants were successful in implementing the exclusion instruction. Every word in the supraliminal condition was correctly reported at the awareness check. In addition, completions of corresponding stems indicated 99.1% accuracy in excluding supraliminal words. That is, participants produced the supraliminal word in stem completion in only 9 of 992 trials (presumably because they failed to think of another suitable completion).

DISCUSSION

Stem-completion performance provided evidence of unconscious processing giving rise to conscious processing; subliminal primes were produced as completions at a rate significantly higher than the baseline rate, and participants were undoubtedly aware of the words they produced. Importantly, subliminal priming was interactively influenced by participants' general proneness to anxiety and the affective valence of the words. Greater priming for threat than neutral words was observed in the high-TA group, whereas greater priming for neutral than threat words was observed in the low-TA group. These findings could be argued to model intrusions of threat information as a consequence of unconscious processing of threat among anxious individuals.

To ensure that words in the subliminal condition were indeed subliminal, three procedural measures were taken. First, an SOA at least 8.3 ms below each participant's individually assessed threshold was applied in the subliminal condition. Second, before priming was assessed, an awareness-check procedure was stringently applied to ensure that words in the subliminal condition did not become visible after word repetition and possible adaptation during the emotional Stroop task. Third, the exclusion procedure functioned to prevent any word that became conscious either before or after the three-letter stem appeared from being given as a

completion. Successful exclusion of supraliminal words indicated that participants were able to avoid using consciously perceived words as completions. Their systematic failures to exclude subliminal words thus should be attributed to a lack of awareness of those words rather than to a breakdown in inhibition. By asking participants to describe their experiences on subliminal trials, we were able to use so-called subjective measures of conscious experience, as previously advocated for confirming unconscious processing (Mayer & Merckelbach, 1999; Merikle, Smilek, & Eastwood, 2001). Above-baseline completion performance on subliminal trials can therefore be regarded as a valid indication of priming due to unconscious processing of specific lexical or semantic knowledge.

Intriguingly, baseline completion was also influenced interactively by TA and affective valence. As expected, participants occasionally completed a baseline stem to the corresponding word, even though that critical word had not been presented. Low-TA individuals produced more baseline threat words than baseline neutral words, whereas high-TA individuals produced baseline threat and neutral words at equivalent rates. Enhanced memory for emotional items among normal individuals is well established (Dolan, 2002). Thus, facilitated access to emotional items from the participant's lexicon and/or a bias due to the regular presentation of threat words in the supraliminal condition may thus account for more frequent baseline completion of threat than neutral words among low-TA individuals. In contrast, a strategic tendency among high-TA individuals to avoid responses with negative meanings (Williams et al., 1997) may have counteracted preferential access to threat words and resulted in comparable baseline frequencies for threat and neutral words. These speculations, however, require further empirical validation.

Note that the observed interaction of valence and TA on priming pertained to the influence of previous presentation on completion rates for critical words over baseline levels. Given the strong valence effect on baseline stem completion in the low-TA group, one might question whether the priming of neutral words but not threat words in this group only emerged due to a ceiling effect. That is, perhaps the completion rate for subliminal threat words failed to increase from its baseline because the baseline rate (14.8%) was too close to some maximal stem-completion rate. This possibility seems unlikely in the face of a numerically higher (albeit non-significantly higher) completion rate for subliminal threat words in the high-TA group (18.8%). Furthermore, the priming effect on neutral words in the low-TA group accords with emerging evidence from cognitive neuroscience research in non-anxious individuals showing that subliminal neutral information can evoke greater brain responses than subliminal threat information (Etkin et al., 2004; Li et al., in press).

Behavioural evidence for unconscious priming in the present experiment relied on backward masking, a powerful method for blocking conscious perception that results in a substantial reduction in the amount and duration of neuronal firing in visual cortex (Dehaene et al., 2001; Macknik & Livingstone, 1998; Rolls, 2004). We speculate that a route via the subcortical colliculo-pulvinar-amygdala pathway may still have been effectively activated by subliminal stimuli (Morris & Dolan, 2001; Whalen et al., 1998), and perhaps exaggerated by anxiety (Etkin et al., 2004; Mathews, Yiend, & Lawrence, 2004; Rauch et al., 2000; Stein, Goldin, Sareen, Zorrilla, & Brown, 2002). An intriguing prediction is that subliminal threat words may yield greater amygdala activation among anxious than among non-anxious individuals, which then may augment weak activation of association visual cortex from the cortical geniculostriate route. We speculate that threat-related meaning representations may sometimes receive slight activation during the course of a day. A fleeting perception of a word like "cancer", normally imperceptible, may activate threat-related processing in an anxious individual, and break through into consciousness as a worrying thought about cancer.

Priming could have been produced by a perceptual bias whereby high-TA participants were inordinately influenced by subliminal threat. Alternatively, subliminal threat processing might have been equivalent in the two groups, but there was a bias to threat processing in the high-TA group at the time of stem completion. Notably, this bias to threat at retrieval would have to relate to the influence of subliminally presented primes rather than merely to retrieving words from the lexicon, given that the baseline condition did not produce the same patterns of completion. In short, the influence of TA on priming could reflect group differences in subliminal perception, or in the use of that subliminally encountered information during stem-completion, or both.

A limitation concerns the failure to match within-set semantic relatedness among threat words and neutral words; threat words were all semantically related to a common concept (threat), whereas neutral words did not come from a unifying semantic category. This categorical influence might have led to enhanced priming for threat words compared to neutral words. However, there was no overall enhancement of priming for threat words, suggesting that this confound is insignificant in the current study and thus does not detract from the validity of the central findings of threat-related processing differences between high- and low-TA individuals.

It might also be argued that our exclusion instructions, intended to model the tendency for people to try to keep intrusive ideas from coming to mind, might have had just the opposite effect. That is, perhaps these instructions caused participants to try very hard to imagine or recall what the previously presented word could have been, in order to be able to avoid that word.

Indeed, the leading model of thought suppression—Wegner's (1994) ironic processes model—posits that the paradoxical effects of thought suppression that are observed under some conditions are due to activation of the very representation that one is trying to suppress (to monitor success of the suppression process). However, although the "ironic monitoring process" is hypothesised to be subconscious, the Wegner model explicitly incorporates only the case in which the individual is conscious of the target of suppression. Moreover, the conditions usually thought of as being necessary to produce paradoxical effects of suppression—high concurrent load or stress—were not present in the current investigation. Finally, the results reported above clearly show that rebound effects did not occur in the supraliminal condition, as exclusion failure occurred only 0.9% of the time. Therefore, it is unlikely that paradoxical thought rebound was involved in this study.

One outstanding question is whether the exclusion instructions might have enhanced the priming effects in the subliminal condition. Given that we did not manipulate the presence versus absence of this instruction, we certainly cannot rule out this possibility, and a replication including such a manipulation is necessary to answer this question. It is worth noting, however, that if such a study did reveal that the exclusion instructions enhanced the priming effects in the subliminal condition, the results would force a reformulation of our current models of suppression. That is, as noted above, whereas the leading model in this area does incorporate a subconscious process in its account of suppression, the initial decision to suppress is seen as being fully conscious (Wegner, 1994). If exclusion instructions do enhance the subliminal priming effects observed here, it would suggest the fascinating possibility that not only is the ironic monitoring process subconscious but that one could even initiate suppression of a specific representation prior to becoming conscious of it.

Finally, although we described valid reasons for choosing the BIS to assess the construct of trait anxiety and we are not aware of any published critiques refuting the superiority of the approach to measuring trait anxiety embodied by the BIS, there are likely to be different opinions within the field on the best approach. Future studies including other widely used trait anxiety scales and scales tapping certain related personality traits and emotion states (e.g., neuroticism and state anxiety) would be useful as they would have the potential to provide either convergent evidence or evidence regarding the incremental validity of the alternative measures for the effects obtained here.

In summary, stem-completion rates for critical words were increased after those same words appeared under conditions that severely restricted conscious word perception, and participants were instructed not to produce those words. When a word is perceived subliminally, there is apparently an

increased tendency to produce that word a moment later, and thus to consciously apprehend that word. Importantly, this subliminal priming was greater for threat words than for neutral words among high-TA individuals. In contrast, the opposite pattern was observed among low-TA individuals, which is in accordance with previous evidence for threat avoidance among such individuals (MacLeod & Mathews, 1988; Mathews & Mackintosh, 1998). These observations may shed light on unconscious influences on intrusive worries and obsessions in anxiety. The findings support the notion that unconscious processing of threat among highly anxious individuals tends to break through into consciousness. A scenario whereby unconscious threat processing among highly anxious individuals leads directly to anxious thoughts may constitute an important mechanism responsible for the development and maintenance of anxiety.

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APPENDIX

Word Lists

Set A	*Set B*	*Set C*
Threat		
Grieve	mutilate	panicky
Unloved	persecuted	strangle
Devastate	blunder	fright
Gloomy	casualty	incurable
Punish	torment	lethal
Ridicule	ambulance	paralysis
Collapse	corpse	insult
Reject	dread	wretched
Sinister	assault	horror
Hostile	fatal	tumour
Cancer	crash	terror
Funeral	wound	defeat
Grave	suffer	tragic
Accident	violent	destroy
Murder	disease	danger
Enemy	attack	failure
Length = 6.75	Length = 6.69	Length = 6.75
Frequency = 21.75	Frequency = 21.06	Frequency = 22.5
Neutral		
Geometry	bungalow	subscribe
Divert	washer	brochure
Slogan	formality	multitude
Pastel	celery	claret
Flannel	tomato	adapt
Genial	racket	revise
Tapestry	feather	elephant
Apprehend	junction	drawer
Absorb	carpet	integral
Fountain	battery	convey
Holder	garage	remark
Quantity	museum	campus
Shear	furniture	thermal
Decade	mantle	domestic
League	sharp	exchange
Record	bottle	bridge
Length = 6.81	Length = 6.63	Length = 6.94
Frequency = 25.81	Frequency = 21.88	Frequency = 24.3