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A Laboratory Method for Investigating Influences on Switching Attention to Task-Unrelated Imagery and Thought

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Thought-intrusions, automatic inferences, and other unintended thought are beginning to play an important role in the study of psychiatric disease as well as normal thought processes. We examine one method for the study of task-unrelated imagery and thought (TUIT). TUIT likelihood was shown to be reliably measured over a wide range of vigilance tasks, to have high short-term and long-term test-retest reliability, and to be sensitive to information processing demands. Likelihood of TUITs was shown to be different as a function of aging, hyperactivity, time of the day, and level of depression. Thus, we now can reliably measure the influence of endogenous and exogenous influences on TUITs. In addition, TUIT measurement was proposed as a minimally interfering and natural second task for determining resource utilization in a primary task. Finally, this method was offered as a reliable approach to quantification of such mental states as obsessions and drug craving and addiction.

Considerable research with retrospective questionnaires of daydreaming and mindwandering (see, for example, Giambra, 1977–1978, 1979–1980; Singer, 1975a, 1975b, 1978), thinking-aloud procedures (see, for example, Pope, 1978) and thought sampling procedures (see, for example, Hurlburt, Lech, & Saltman, 1984; Klinger, 1978, 1971; Klinger & Cox, 1987–1988) have demonstrated the ubiquity of task-unrelated images and thoughts (TUITs). TUITs may represent the normal default mode of operation of the self-aware, i.e., conscious, mind (see Singer, 1975a, 1978). That is, when information from the external world does not demand processing or does not use all available cognitive capacity, then excess capacity can be devoted to processing information of an internal origin, TUITs. Viewed from this perspective TUIT occurrence and unused capacity, when performing a task, are directly proportional. Thus, TUIT production is the result of an endogenous, secondary process of a dualistic system of human information processing.

Psychologists have long been aware, albeit by a different terminology, of TUITs and the process that leads to them. The problem solving process has often been described as a four-step sequence: Preparation, incubation, illumination, and verification (Johnson, 1972). Illumination is the spontaneous occurrence of problem solving thoughts. Incubation is the nonconscious processing of the information contained in the problem components provided at the initial definition of the problem and the preliminary attempt at solution. The thoughts which occur at illumination are often insightful. Insights are especially valuable forms of TUITs. Thus, the study of characteristics of TUITs and of the processes that generate them can provide salient information about insightful processes.

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Today we find increasing interest in other manifestations of TUITs such as spontaneous trait inferences, automatic social judgments, and other forms of non-conscious information processing in social situations. Also, we find keen interest in the automatic and intrusive thoughts and ruminations exhibited in depression, obsessional disorders, Post-Traumatic Stress Disorder, and stress in general (see Davidson & Baum, 1986; Lewicki, 1986; Uleman & Bargh, 1989; Zilberg, Weiss, & Horowitz, 1982). In these cases it is the content of TUITs which are important and of great interest because they may provide us a window into an individual's pathology as well as provide expression of his or her current concerns (Klinger, 1971, 1977, 1978; see Singer, 1990, for a review). Despite their commonness, TUITs have received little attention in cognitive psychology. Knowledge of the influence of exogenous and endogenous variables on TUIT production may tell us a great deal about the activities of the mind and factors that influence the mind's activity. This paper provides empirically based information about a methodology which contributes to the fruitful study of TUITs.

TUITs may occupy awareness because they capture our attention—an uncontrolled shift—or because we have deliberately shifted our attention to them—a controlled shift. A shift of attention to TUITs may take one of two sequences: (a) a TUIT occurs then an attentional shift to it, (b) an attentional shift away from external perceptual stimuli then a TUIT occurs. The first sequence implies that TUITs may occur in parallel with perception of and response to the external world. The second sequence implies attention to the external world and attention to TUITs in consciousness are mutually exclusive and must occur serially. Antrobus, Singer, Goldstein, and Fortgang (1970) in their experimental study of TUITs concluded that TUITs are processed both serially in the intervals between the processing of external or sensory stimuli and in parallel with perceptual processing. When the deliberate attentional shift follows the TUIT, we can infer that the TUIT was more compelling than the task at hand. When a TUIT follows the deliberate attentional shift, we can infer that the task at hand was sufficiently uncompelling as to force us to seek an internally generated, i.e., mental, stimulus. Voluntary shifts of attention to TUITs would seem to involve higher orders of control in information processing or be motivationally determined and to be benign because of their controlled nature. However, involuntary shifts of attention from the task at hand to TUITs would seem to involve lower orders of control in information processing and not motivationally determined; in addition, involuntary shift may be less benign because they are uncontrolled.

Are involuntary shifts of attention to TUITs part of the natural rhythm of our information processing biological apparatus, i.e., endogenous time-linked attentional control operators which shift attention to mental events, or are the shifts situationally determined, or both? Thus, after some time interval, a shift of attention to a mental event may be unavoidable and unstoppable, see, for example, Antrobus, Singer, and Greenberg (1966). Individuals whose intervals are short may be viewed as impaired, as in attention deficit disorders. The factors which determine the interval to the next involuntary shift may be fully endogenously determined, fully situationally determined, or function of both, additively or interactively. Psychology has had a long-term interest in the study of involuntary attention switches from one external stimulus to another external stimulus as is evident in the voluminous literature on the orienting response (at least 123 papers from 1987 to 1992), the Stroop Effect (at least 100 papers from 1987 to 1992), and the "pop-out" effect (at least 6 papers from 1987 to 1992). However, cognitive psychology has given little attention to involuntary attention switching to mental events, i.e., TUITs. This paper provides empirically-based information about a methodology for studying the relationship between TUITs and shifts of attention.

To adequately measure exogenous and endogenous influences on TUIT production, a reliable and valid "meter" is needed. Below an empirically tested method that is the equivalent of having a meter that allows for, minimally, ordinal scaling of TUIT production is described. It is a meter that measures TUITing without regard to its specific content, emotional tone, emotional intensity, or personal salience. With this method, one can determine the degree to which individuals generally differ in their TUITing or the degree to which two situations differentially influence TUITing in the same individual.

An ideal method would be independent of the person's awareness and would not influence TUIT production in any way. This ideal is unobtainable at the present time. A method based on electrophysiological indices is conceivable, but is not yet adequately developed, see Antrobus, Antrobus, and Singer (1964). What remains is a method that is derived from self-report and has its origins in the earlier work of Antrobus and Singer (see, for example, Antrobus, 1968; Antrobus et al., 1970; Antrobus et al., 1966; Singer, 1978). The ideal self-report method would require that a subject indicate when a task-unrelated image or thought begins and when it ends. However, as a preliminary investigation showed, when subjects were asked to be aware of and report the start of a TUIT, this usually resulted in its termination.

Alternately, we can require that a subject to be aware of and indicate when a TUIT ended. The TUIT-end method has been used successfully to describe age differences (Giambra, 1989) but is limited to being only a frequency measure of TUITs. TUITs of every duration contribute equally to it. Two subjects with the same number of TUIT endings can have very different total time intervals devoted to TUITs. For example, if subject S1 has ten 1-s TUITs and subject S2 has one 1-s and nine 10-s TUITs, then the TUIT-end method would indicate that S1 and S2 have equal TUIT tendencies. It is clear that S2 has the greater propensity to TUITs. On the other hand, two subjects with a different number of TUIT endings can have identical TUIT likelihoods. For example, S1 has ten 1-s TUITs and S2 has one 10-s TUIT. One condition under which this distortion would be greatly attenuated is when everyone has the same mean duration of their TUITs. Another condition under which the distortion would be minimal is when the population distribution of mean TUIT durations is symmetrical and a sufficiently large sample of subjects is used—so that subjects whose TUIT likelihoods are overestimated or underestimated are equally represented. At present, there is no evidence regarding mean TUIT durations for individuals or the distribution of TUIT durations.

To overcome the weaknesses of the TUIT-end method we employ the "probe-TUIT" measurement method. In the probe method the observation interval is partitioned into equal time periods and the subject indicates, by a positive response at the end of each period, if at least one TUIT occurred in that period. If the probe period is too long, then the number of positive responses is too gross an indicator of TUIT likelihood. If the probe period is too short, then the rapid signaling of the end of a probe period could greatly interfere with the ongoing processes. Earlier testing in my laboratory (see, Giambra, 1989) and the work of Antrobus, Singer, and associates (Antrobus, 1968; Antrobus et al., 1970; Antrobus et al., 1966) supported the appropriateness of a probe period of about 15–30 s as largely avoiding both the crudeness and the interference shortcomings.

In the probe method, subjects with widely varying numbers of TUITs that occupy about the same amount of total time would each respond by a single positive response to the probe signal. For example, one 20-s TUIT and four 5-s TUITs would both produce a single positive probe signal response. This is appropriate since both cases involve 20 s of ongoing TUITs. The greatest distortion to accurate measurement of TUIT propensity would occur when only a single 1-s or only a single 30-s TUIT takes place in a 30-s probe interval. This places a clear, controllable upper limit on the distortion of the probe-TUIT method that was not present with the TUIT-end method.

The usefulness of the probe-TUIT method for measuring task-unrelated imagery and thought propensity is demonstrated in this paper by showing its sensitivity to conditions of the concurrent task and to its reliability in maintaining consistent individual differences over different task conditions, different tasks, and widely time-separated measurement periods. Antrobus (1968) used a probe-like method to determine TUIT likelihood and determined that TUIT likelihood varied linearly as the information processing demands of the task varied linearly.

Antrobus (1968) demonstrated that some ostensibly purposeful primary task must serve as an environment within which task-unrelated images and thoughts manifest themselves. Antrobus (1968) also demonstrated that the primary task should be one where demand on the subject's information processing resources can be controlled. A vigilance or sustained attention task was selected as our primary task. In a vigilance task, events usually appear regularly over an extended interval and events requiring a response, i.e., targets, appear irregularly. The targets are usually relatively rare events. Task demand can be easily controlled by the event rate and the proportion or number of targets. The vigilance task is well suited because it allows for a high degree of control over the kinds and degree of stimulation a subject receives, because it is very simple with clearly stated goals and actions and because it can be long-term without great stress. These characteristics were desirable because: (a) we wished to tie TUIT likelihood to resource allocation in an orderly manner to again demonstrate that TUIT awareness by subjects was reliable (Antrobus, 1968; Antrobus et al., 1970), (b) we wished a relatively impoverished stimulus environment which permitted the expression of TUITs while not capturing attention or evoking stimulus-based thoughts; and (c) we wished a task which was so easy to understand that subjects would not need to devote many resources to task-related thoughts.

EXPERIMENT 1

Our primary goal was to find a vigilance task whose information processing demands allowed for the expression of a wide range of TUIT propensities and which could be repeated many times with few learning effects. We sought to demonstrate, using the probe-TUIT method, that the resource utilization of the vigilance task was inversely related to TUIT likelihood and that individual differences in TUIT likelihood were maintained across different levels of task resource demand and pretask conditions. Resource utilization was controlled by two powerful psychophysical parameters, event rate and signal (target) probability (see, Davies & Parasuraman, 1982, for a thorough review). More information must be processed when event rate is increased and more attention demanding resources are used when more signals demand a response—TUIT likelihood to decrease as event rate increased and as signal probability increased.

Method

Subjects and design. Ten men (17–27 years old) and 16 women (19–36 years old) participated. Subjects were paid ($150.00) volunteers who were recruited from Towson State University, from an African-American sorority, through bulletin board advertisements at the Gerontology Research Center and through word-of-mouth. None were employees of the Laboratory of Personality and Cognition. All subjects were in their first year of college or had at least 1 year of college education. Each subject indicated all drugs that he or she was using. Subjects taking drugs which could interfer with performance were excluded. During the study were: (a) asked to report the taking of any new drugs, both legal and recreational, that might influence performance; (b) told to refrain from recreational drugs and alcohol for at least 12 h prior to their participation in an experimental session; and (c) were informed that failure to report drug usage accompanied by erratic or unusual behavior would be taken as obvious evidence of unpermitted drug usage and their participation in a session cancelled—however, no subjects showed such behavior and no sessions were cancelled.

A Percent of Targets (10%, 30%) × Interevent Interval (2, 8, 32s) × Pretask (Grid Game, Mental Puzzle) factorial design was used. Event rate per minute was 60/(IEI + 1) since all events were exposed for 1 s. Repeated measurements were used across all 12 conditions. Order of presentation was determined by a Latin Square of size 12; however, two orders were overrepresented.

Apparatus. A microprocessor controlled the color video monitor that displayed the stimuli. The monitor was placed on an adjustable platform of a 76 × 152 cm terminal table. The front of the table had an adjustable keyboard platform on which was placed a 40 × 6.5 cm box containing four horizontally aligned 1.8 × 1.8 cm response buttons. The left-center response button was labeled TARGET while the right-center response button was labeled TUT. The two end buttons were used only during instructions. All responses were recorded in the memory of the microcomputer to 16-ms accuracy. The microcomputer was located in a separate room and kept a timed record of stimulus presentations and button presses.

Procedure. Each subject participated in 12 sessions. Each session consisted of the pretask, a 5-min practice vigilance task, and the experimental vigilance task.

It is evident, from personal introspection and from the work of Antrobus et al. (1966), that events prior to a vigilance session could influence the number of TUITs during the vigilance session. Two very different previgilance tasks were used, an uninteresting video game and mental puzzles. Both pretasks were for 20 min. The mental puzzles, usually unsolved, were expected to produce more TUITs based upon the expectation that mental work on the puzzles would continue during the relatively boring vigilance task.

The goal of the video game was to move a marker to a position in a 5 × 5 enclosed grid that would add one point to the subject's point total. Movement could only be down or to the right. Each game started with the marker located in the upper left hand corner of the grid. Marker movement was obtained by pressing one of two response buttons labeled with a down or side arrow. Subjects were told that their task was to obtain as many points as possible. No information was provided on the target location. When the target location was reached the monitor informed the subject a point had been gained and the continuously displayed game point total was incremented by one. The market then returned to the starting position. Any move that would place the marker outside the grid terminated the sequence, flashed an error message, and moved the marker to the starting position.

Work toward puzzle solution was began immediately after the mental word puzzle was presented in writing. Possible solutions were presented to the experimenter who indicated its correctness. A correct solution lead to the presentation of a second puzzle; an incorrect solution lead to continued work on the original puzzle.

In all vigilance tasks the neutral event was a single green circle and the target event was a linear horizontal arrangement of three red squares. All stimuli were centered on the video minitor screen. The practice vigilance task was preceded by instructions. The experimenter left the room during both practice and experimental vigilance tasks but returned between tasks. The practice vigilance task had a 5-s interevent interval, 50% targets, and a 5-min duration. There were six different, 33-min experimental vigilance tasks. The 2-s interevent interval had 660 events, the 8-s interevent interval had 220 events, and the 32-s interevent interval had 60 events. The events were partitioned into blocks of 10. Within a block of 10 events the location [1st, 2nd, . . . , ith, . . . , 10th position in block] of the target(s) was determined by random selection in which all position numbers were equally likely. For 10% targets one position was selected in each block while for 30% targets three positions were selected in each block. The same order was used for all subjects. Each task was one of the six Percent Targets–Interevent Interval combinations: 10%–2 s, 10%–8 s, 10%–32 s, 30%–2 s, 30%–8 s, 30%–32 s. When the target was observed the subject was to respond immediately by a button press of the TARGET button located on the response box below the monitor screen.

The 33 min of the vigilance task were divided into 68 contiguous intervals of 29 s. These "probe" intervals were delimited by the occurrence of a double beep that ended each interval; the first double beep was coincidental with the start of the vigilance task.

Subjects were instructed that they would sometimes find themselves thinking about something other than the vigilance task and that these thoughts occur spontaneously and are not stimulated by something they sense in their environment or within themselves. These thoughts we called task-unrelated thoughts (TUTs) and if he or she had one or more of them since the last double beep to indicate that by pressing the button labeled TUT located on a response panel below the monitor screen. The practice session, as well as additional verbal instructions and questioning by the experimeter, assured that the subject understood the task and the definition of a task-unrelated image or thought. The experimenter remained in the testing room during instructions and occasionally during the practice vigilance task. At all other times the experimenter observed the participant through a one-way mirror.

Ericsson and Simon (1980) report that verbal reports of the contents of consciousness would be most accurate when: (a) the reports are collected within a few seconds of the original experience, (b) there is foreknowledge that the experience is important and requested, and (c) the experience occurs when information processing demands on short-term memory are low. Awareness of, and reports of, TUITs by a button press is itself a minimal report of the contents of consciousness. The vigilance tasks themselves are relatively low in information processing demands. Thus, an expectation of high accuracy for TUIT awareness would seem to be reasonable by the Ericsson and Simon criteria.

After a session was completed the experimenter reentered the testing room and asked questions regarding task difficulty, interference between the vigilance and TUIT reporting tasks, sleepiness, and estimation of TUIT frequency and length. A full session took from 75 to 90 min. Participants who were observed or admitted to sleeping for more than a minute during a session were required to satisfactorily repeat that session at the end of the 12 original sessions. For nine subjects, a total of 11 sessions were repeated due to sleeping or to other problems with the session. Usually, sessions were held on consecutive days at the same time of the afternoon.

Results and Discussion

A 2 (Percent of Targets) × 3 (Interevent Interval) × 2 (Pretask) completely within-subjects analysis of variance (ANOVA) was carried out on the number of probe intervals with at least one TUIT occurring in it—henceforth referred to as "P-TUIT frequency." Significant effects were obtained for Percent of Targets, $F(1, 25) = 6.50$, $p < .05$, and for Interevent Interval, $F(2, 50) = 10.76$, $p < .01$. All other effects and interactions were nonsignificant, $p > .20$, with all having F values of 1.52 or smaller. The mean P-TUIT frequencies were 45.0 and 42.5, respectively, for 10 and 30% targets and were 40.3, 44.9, and 46.0, respectively, for 2-, 8-, and 32-s interevent intervals, see Fig. 1. Thus, those vigilance tasks that made greater demands on external attention resulted in fewer task-unrelated images and thoughts. However, from a general resources perspective these tasks

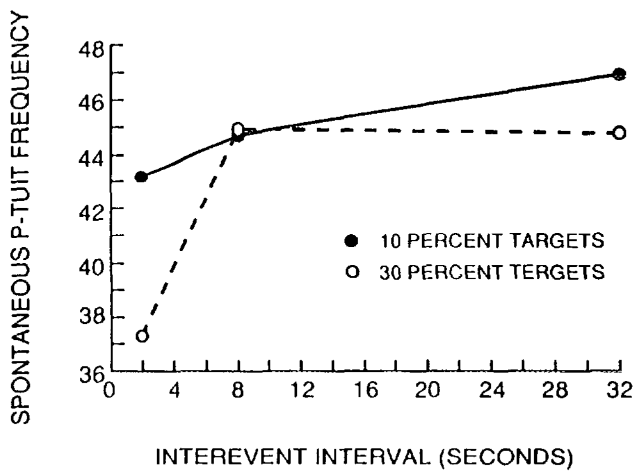

FIG. 1. Experiment 1. The frequency of P-TUITs as a function of signal probability and interevent interval.

were very undemanding. The mean detection accuracy was 98.0%—six subjects had 100% accuracy on all tasks and the poorest performance was 96.4%. As already reported, Antrobus (1968), found a similar relationship between task demands and TUIT likelihood. As would be expected from the minimal variability in detection accuracy, there was no relationship between accuracy and TUIT production (mean $r = .03$).

Gender differences were examined in a Gender × Percent of Targets × Interevent Interval × Pretask ANOVA. Neither gender as a main effect, $F(1, 24) = 2.11$, nor any of its interactions were significant, all $F < 2.52$, $p > .05$. The 12 conditions were experienced approximately equally 1st, 2nd, 3rd, . . . 11th, 12th. A nonsignificant position effect was obtained, $F(11, 264) = 1.32$, $p > .05$, in an ANOVA.

Target response time was faster for 30% targets (624 ms) than for 10% targets (680 ms) as would be expected in a vigilance task, a result consistent with the vigilance literature (see, for example, Parasuraman & Davies, 1976). Target response time was quicker with faster event rates. In this experiment, the rates were 1.8/min (rt = 740 ms) 6.7/min (rt = 666 ms), and 20/min (rt = 550 ms). These results are the inverse of those reported in the vigilance literature (Davies & Parasuraman, 1982). Parasuraman and Davies (1976) found a faster response time for correct detections with an event rate of 15/min than with an event rate of 30/min. Perhaps, the relationship of response time to event rate is U-shaped when the range of rates include very low values. Of course, the requirement that TUITs be reported and that prompts occurred every 29 s in this experiment may have been responsible for this unique outcome. Analyses of variance confirmed that these effects were significant, $F(1, 24) = 34.81$, $F(2, 48) = 39.24$, respectively, for percentage of targets and IEI effects, $p < .01$.[1] No association was found between target response time and P-TUIT frequency, the mean correlation was $-.04$ across the 12 sessions.

Any method for measuring TUIT propensity should be sufficiently robust so as to preserve differences between individuals across modest changes in the method or task parameters. The different levels of target percentages and inter-event intervals represent different parametric values (with a vigilance primary task) for the probe-TUIT method of measuring TUIT propensity. Thus, the 15 correlations, for P-TUIT frequencies, among the different target percentage–IEI combinations are an indication of the robustness of the probe-TUIT method. The correlations ranged from .58 to .88 (M = .76) within the Grid Game pretask, from .62 to .92 (M = .80) within the Puzzles pretask, and from .78 to .96 (M = .86) when P-TUITs summed across both pretasks.

Furthermore, when the probe-TUIT method is used on the same group of individuals at different points in time the relative TUIT propensities of the individuals ought to be preserved as long as there are no substantive changes in the individuals. The different pretasks, each vigilance task condition [target percentage–IEI combination], provided a separate repeated testing of identical probe-TUIT methods separated by 1 to 14 days. The correlations between the two pretasks ranged from .68 to .90 (M = .77) for the six target percentage–IEI combinations.

After each session subjects were asked if keeping track of targets interferred with pressing the TUIT button and if pressing the TUIT button interferred with keeping track of targets. Of the 26 subjects, 6 denied either type of problem on any of the 12 sessions. Of the remaining 240 sessions (with the remaining 20 subjects), 30 had at least one occasion when a target interferred with recording a TUIT and 39 had at least one occasion when keeping track of TUITs interferred with responding to targets. Most problems of either sort occurred during the first or second session and when targets and probe "beeps" were simultaneous or near simultaneous. On some occasions subjects simply pressed the erroneous button. These problems, when they happened, usually occurred once or twice a session. Subjects did not report that they had more TUITs because they were asked to be aware of TUITs. Certainly, if the request for self-awareness of TUITs primed the subjects for TUITs the effect was not so strong as to put most, or even the majority of subjects, at or near maximum. The probe technique, i.e., the periodic beeping, might have influenced vigilance performance by making the subjects more alert. However, this is difficult to determine since the vigilance tasks were, on an absolute basis, very easy. Certainly, the concurrent tasks of the sessions—awareness of TUITs, TUIT acknowledgment, target awareness, and target response—all placed demands on a limited set of resources. If that resource demand exceeded available resources, then some aspect of the task might suffer. It is possible that the primary effect of these demands was not a

[1] One subject had equipment problems in recording response time on 1 of the 12 sessions. Hence, subject was eliminated from repeated measures ANOVA.

lack of response but a delay in response, i.e., TUIT and target button presses occurred more slowly than if either alone were required. If the central task was demanding and the salience of the central task was properly emphasized, then TUITs should have been sacrificed, rather than the central task performance.

This experiment demonstrated that the probe-TUIT method, with a vigilance primary task, can reliably reflect individual differences in task-unrelated imagery and thought likelihood. Furthermore, the relative individual differences in TUIT likelihood were preserved across the changes in the vigilance task parameters, i.e., as vigilance task demand varied P-TUIT frequency changed in a similar manner for most individuals.

Another purpose of the experiment was to find a vigilance task that has a combination of parameters which, when repeated under different conditions, adequately reflected the different TUIT likelihoods of these different conditions. Although any criteria for assessing optimality were essentially arbitrary, a vigilance task was considered "optimal" when: (a) both high and low TUIT likelihoods were evident and (b) both high and low TUIT likelihood individuals were not operating at ceiling and floor levels, respectively, and changes in experimental conditions were reflected in changes in P-TUIT frequencies.

The maximum number of probe intervals was 68. The first criterion would be met by a rectangular frequency distribution of P-TUITs over most of the 0 to 68 possible range. The second criterion would be met by requiring the median P-TUIT frequency to be at 34, the middle of the 0 to 68 range, or by finding a vigilance task that permits the greatest percentage of subjects the opportunity to change their P-TUIT frequency the greatest amount. Table 1 provides the sample distribution of P-TUIT frequency as well as the means, medians, and number of subjects who have the potential to change their P-TUIT frequency by 10 or 20% for each condition. Nearly all of the combinations of percentage of targets and interevent interval showed an overrepresentation at the high end of the P-TUIT frequency distribution (negative skewing). The 30%–2-s combination had a median at or near 34 and the largest proportion of subjects who can change the most in either direction. The best candidate for a paradigmatic vigilance primary task, using the probe method, has 30% targets and a two second interevent interval; the second and third candidates appear to be the 10%–2-s and the 10%–8-s combinations.

EXPERIMENT 2

In Experiment 1 it was demonstrated that, with vigilance as the primary task, the probe method allows for measurement of task-unrelated imagery and thought that is sensitive to individual differences. Furthermore, the relative TUIT propensity levels among individuals were maintained over a range of vigilance parameter values that represent modestly different demands on the external attention of the subjects. Experiment 2 extended Experiment 1 by examining the stability of TUIT likelihood differences when the intersession interval was from 5 to 13 months, when the vigilance task was presented in an auditory mode, and when an additional judgement regarding the extent of subject control of TUITs was required.

TABLE 1

Sample Distribution of P-TUIT Frequency, Medians, Means, and Number of Subjects Who Have the Potential to Change Their P-TUIT Frequency by 10 or 20% for the 12 Conditions of Experiment 1

Percent of targets:	10%						30%					
Interevent interval:	2 s		8 s		32 s		2 s		8 s		32 s	
Pretask:	G[a]	P	G	P	G	P	G	P	G	P	G	P
Number of P-TUITs												
00–10	2	2	2	2	1	2	2	6	2	2	3	1
11–20	4	2	3	2	3	3	4	3	2	1	2	4
21–30	3	3	3	3	3	3	4	2	4	5	3	4
31–40	4	3	2	3	1	2	7	2	3	2	3	3
41–50	0	3	2	3	3	4	0	4	1	3	1	0
51–60	5	3	3	2	1	2	2	3	3	3	3	5
61–68	8	10	11	10	13	10	7	6	11	10	11	9
Median No. P-TUITs	38	49	51	47	58	45	34	37	47	44	48	55
Mean No. P-TUITs	42	44	46	44	49	45	38	37	45	45	45	44
Can increase and decrease												
by 10%[b]	18	18	15	17	13	16	20	19	15	16	15	17
by 20%	13	14	13	15	11	14	18	17	14	14	14	12

[a] G, Grid; P, Puzzle.

[b] This measurement refers to those subjects in the distribution, out of 26, who have a P-TUIT frequency sufficiently less than the maximum or sufficiently greater than the minimum so that changes in probe-TUIT frequency as great as 10 or 20% can occur.

In Experiment 1, the subject was required to be aware of unbidden TUITs. However, for some individuals that judgement may be difficult or ignored. That is, individuals may be reporting any unrelated thoughts, whether unbidden or deliberate. Therefore, the extent to which individuals can report both deliberate and unbidden TUITs and the influence of requiring them to report both were also investigated.

Method

Subjects and design. Of the 20 participants of Experiment 1 who could be reached, 9 women (19–35 years old) and 6 men (17–26 years old) agreed to participate in Experiment 2. The interval between the last session in Experiment 1 and the first session Experiment 2 was 5 to 13 months ($M = 12$). There were three parts to this experiment. The first part consisted of an exact duplication of three vigilance conditions and their TUIT reporting requirements of Experiment 1 (1 male had a computer malfunction during one of the three vigilance conditions). The second part was three auditory analogs to the duplicated visual vigilance tasks. The final part was also a duplication of the three vigilance conditions of the first experiment, but subjects were required to report separately on both deliberate and unbidden TUITs (1 male did not participate in this part of the experiment). The exact duplication and auditory analog sessions were carried out first. These six sessions were randomly assigned numbers 1 to 6 and a Latin Square was used to determine the order of the sessions for each subject. A Latin

Square of size 3 determined the order of presentation of the vigilance tasks where deliberate and unbidden TUITs were reported. These sessions were carried out last. Participants who carried out all sessions were paid $135.00.

Apparatus. The apparatus of Experiment 1 was used in the exact duplication part of this experiment. The second duplication part of this experiment, requiring reporting of both deliberate and spontaneous TUITs, used the same apparatus as Experiment 1, except that the response buttons were labeled as described below. The apparatus for the auditory vigilance conditions was the same as in Experiment 1 plus two free-standing high-quality speakers driven by an auditory card added to the STD BUSS system.

Procedure and stimuli. For the exact duplication part of this experiment the procedure and stimuli were identical to those in Experiment 1. The vigilance tasks selected were the three most promising candidates for an "optimal" procedure: 30%–2 s, 10%–2 s, and 10%–8 s. For the second duplication part of this experiment (the "two-TUIT" part) the procedure and stimuli were identical to the exact duplication part except for instructions and labeling of the response buttons. Subjects were instructed that:

> We would also like you to try to be aware of the type of TUT [Task-unrelated-thought intrusion] you are having. There are two types of TUTs: 'spontaneous TUTs' and 'deliberate TUTs'. 'Spontaneous TUTs' are task-unrelated-thought intrusions that spontaneously come into your head without any effort on your part. That is, they just 'pop into your head.' Thus, 'spontaneous TUTs' may happen at any time. On the other hand, 'deliberate TUTs' are task-unrelated-thought intrusions that occur when you deliberately try to think about something other than the vigilance game task. We would like you to try to distinguish between these two types of TUTs during this experiment. . . . Whenever there is a double beep, if you happened to have had any spontaneous TUTs since the previous double beep, then press the white [labelled] 'spontaneous TUT' button. On the other hand, if you deliberately produced any TUTs since the previous double beep, then press the green [labelled] 'deliberate TUT' button. If you had both types of TUTs . . . then press both 'TUT' buttons . . .

For the auditory vigilance part of this experiment the stimuli consisted of high (1000 cps) and low (600 cps) frequency tones of 1-s duration. The target stimulus was the higher tone. Target percentage–interevent interval combinations were the same as those in the exact duplication and second duplication ("two-TUIT") parts of this experiment. The major procedural difference was that the end of each probe period was signalled by a double flash of red on the monitor screen. This was done to avoid any confusion brought about by having an auditory probe signal mixed in with the high and low frequency tones of the vigilance task.

As in Experiment 1, a practice vigilance task was performed at every session. Subjects were observed through a one-way mirror during the full session, and care was taken—by quizzing the subject and providing further explanation—to ensure that all instructions and definitions were understood. All vigilance tasks were preceded by the Grid Game pretask.

Results and Discussion

The correlation between P-TUIT frequency in Experiment 1 and the exact duplication sessions, which occurred 12 months later, was very high (M = .81) for

TABLE 2

Correlations among Experiment 1 and the Exact Duplication (DUP), Auditory (AUD), and "Two-TUIT" Parts of Experiment 2 for P-TUIT Frequency for the 10%–2 s, 10%–8 s, and 30%–2 s Vigilance Sessions (Grid Game Pretask)

	Experiment 1					Duplication				Auditory		
			Two-TUIT[a]				Two-TUIT[a]			Two-TUIT[a]		
Session	DUP	AUD	Ei.	Sp.	Del.	AUD	Ei.	Sp.	Del	Ei.	Sp.	Del.
10%–2 s	.78	.59	.60	.71	.43 ns	.83	.66	.50 ns	.55	.78	.27 ns	.78
10%–8 s	.82	.80	.71	.68	.48 ns	.93	.89	.57	.72	.90	.56	.76
30%–2 s	.83	.78	.67	.57	.49 ns	.81	.92	.57	.80	.69	.39	.55

Correlations among the 10%–2-s, 10%–8-s, and 30%–2-s sessions for P-TUIT frequency

	Experiment 1		Duplication		Auditory		Two-TUIT	
	10%–2 s	10%–8 s	10%–2 s	10%–8 s	10%–2 s	10%–8 s	10%–2 s	10%–8 s
10%–8 s	.83	—	.90	—	.88	—	.96	—
30%–2 s	.88	.85	.81	.77	.90	.97	.86	.89

Note. ns indicates $p > .05$; all other correlations are significant, $p < .05$.

[a] The three columns of correlations under the "Two-TUIT" label are for the number of probe intervals, where (Ei.) either a spontaneous TUIT or a deliberate TUIT occurred, (Sp.) a spontaneous TUIT occurred, or (Del.) a deliberate TUIT occurred, respectively.

all three (percentage target–interevent interval) vigilance sessions, see Column 2 of the top half of Table 2. This demonstrated stability of individual differences over an extended time interval. The correlation between the exact duplication (visual) vigilance sessions and the auditory vigilance sessions was also very high ($M = .86$), see Column 7 of the top half of Table 2.[2] This demonstrated that the vigilance task modality had little influence on individual differences in P-TUIT frequency, i.e., that either mode may be used with equal effectiveness.

The "two-TUIT" sessions were more demanding on the subjects, but also provided a great deal more information about the origin of the task-unrelated thoughts and images. It was believed that subjects may have reported both spontaneous and deliberate TUITs in Experiment 1 and in the other parts of this experiment, despite the instructions to report only spontaneous TUITs. When the number of probe intervals where either a spontaneous or a deliberate TUIT occurred was correlated with the P-TUIT frequency in the other sessions of this experiment, the result was a range of correlations from .66 to .92, see Columns

[2] To individuals who work primarily in the field of vigilance these correlations may seem remarkably high relative to the correlations between auditory and visual vigilance tasks when detection accuracy is the dependent measure. Davies and Parasuraman (1982) in their review of such correlations noted that early studies had generally low, $r < .25$, or negative correlations. However, more recent studies, which more closely matched the parameters of the auditory and visual vigilance tasks, have often found correlations as high as .80. Correlations, using detection accuracy, between auditory and visual tasks in these studies are not reported since accuracy levels were all at or very close to 100% that a correlation could not be meaningfully estimated—the mean correct were 99.2, 99.2, and 98.9%, respectively, for the replication, auditory, and two-TUIT parts of Experiment 2.

8 and 11 of the top half of Table 2. This indicated that the additional demand of the two-TUIT sessions had little effect on the apparent relative TUIT likelihoods of the subjects. When the frequency of spontaneous TUITs was correlated with P-TUIT frequency in the other sessions the range was from .27 to .57, see Columns 9 and 12 of the top half of Table 2. When the deliberate TUIT frequency was used the correlations ranged from .55 to .80, see Columns 10 and 12 of the top half of Table 2.

The correlations between spontaneous and deliberate TUIT frequency were .20 ($p > .05$), .35 ($p < .05$), and .17 ($p > .05$), respectively, for the 10%–2-s, 10%–8-s, and 30%–2-s sessions. The correlations between spontaneous TUIT frequency and total TUIT frequency were .47, .54, and .59, respectively, for the 10%–2-s, 10%–8-s, and 30%–2-s sessions (all $p < .01$). The correlations between deliberate TUIT frequency and total TUIT frequency were .91, .90, and .85, respectively, for the 10%–2-s, 10%–8-s, and 30%–2-s sessions. These correlations support the inference that deliberate TUITs were dominating subject reporting of TUITs. Also supporting this inference was the finding that the mean percentage of probe intervals with a deliberate TUIT in it was 70.8, while the mean percentage of probe intervals with a spontaneous TUIT in it was 50.0.

Level (mean) comparisons. For each of the three vigilance tasks the mean P-TUIT frequency was compared in a one-way repeated measures ANOVA across the original testing done in Experiment 1 and the exact duplication, auditory vigilance, and two-TUIT parts of Experiment 2, see Table 3 for means, standard deviations, and F values. A significant, $p < .05$, effect occurred only with the 10%–2-s vigilance session. A series of planned comparisons found that the exact duplication sessions had significantly greater P-TUIT frequencies than

TABLE 3

Frequency of P-TUITs for the 10%–2 s, 10%–8 s, and 30%–2 s Vigilance Sessions (Grid Game Pretask) in Experiment 1 and the Exact Duplication, Auditory, and "Two-TUIT" Conditions of Experiment 2

						ANOVA results[a]	
Session		Experiment 1	Duplication	Auditory	Two-TUIT	$F(3, 36)$	MS(Error)
10%–2 s	M	34.5	49.2[b]	46.9	47.0	4.64*	125.5
	SD	22.6	19.3	21.1	19.1		
10%–8 s	M	42.5	48.2[b]	49.9	44.9	2.41	58.7
	SD	23.1	22.0	21.4	20.3		
30%–2 s	M	36.7	44.7[b]	46.1	43.5	2.48	90.8
	SD	22.6	20.8	20.5	21.9		

Note. Means, standard deviations, and ANOVAs are restricted to the 13 subjects who completed all sessions in each of the four conditions.

[a] The ANOVA results are for a one-way repeated measures across the four "parts" of this comparison (Experiment 1 and Duplication, Auditory, and Two-TUIT conditions of Experiment 2); each vigilance session was done separately.

[b] Indicates that the duplication value was significantly, $p < .05$, different from the Experiment 1 value. Other planned comparisons with the Duplication part of Experiment 2 were not significant.

* $p < .05$ based upon the Greenhouse–Geisser correction.

the original sessions of Experiment 1; all other comparisons were not significant, see Table 3 for means. Since the auditory task and the two-TUIT condition had mean P-TUIT frequencies at the same level as the exact duplication condition, this pattern of significant and nonsignificant differences was most likely the result of a generally higher likelihood of having task-unrelated imagery and thoughts at the second testing period, i.e., the source of this rise was most likely situational. The one common situational component to all Experiment 2 conditions was the previous extensive exposure of Experiment 1. In Experiment 1 a nonsignificant position effect was noted. This ANOVA was carried out again, but restricted to subjects who completed Experiment 2; the position effect was again nonsignificant, $F < 1$. Hence, a common prior experience with TUIT reporting does not explain the higher P-TUIT frequencies at the replications.

However, we did determined that there were significantly fewer P-TUITs on the 10%–2-s Grid Game Pretask session of Experiment 1 for subjects who participated in Experiment 2 relative to those who did not 34.5 vs 52.5, respectively. For the 10%–8-s and 30%–2-s sessions the differences were not significant, but the Experiment 2 subjects did have lower P-TUIT frequencies, $F < 1$, in the original sessions. Perhaps, the greater P-TUIT frequencies in Experiment 2 represent a regression toward the mean.

Target response times were 906, 724, 662, and 640 ms, respectively, for the auditory stimuli sessions, the two-TUIT sessions, exact duplication sessions, and original sessions. The 10%–2-s sessions (rt = 743 ms) were slower than the 30%–2-s sessions (rt = 650 ms), again indicating a signal probability effect, and faster than the 10%–8-s sessions (rt = 806 ms), again indicating an event rate effect. Appropriate ANOVAs confirmed that these effects were significant, $p < .05$, and that no interactions occurred, $p > .05$.

GENERAL DISCUSSION

These results show that baseline vigilance tasks are available that permit reliable measurement of the likelihood of task-unrelated images and thoughts and that permit a wide range in individual differences to be expressed and maintained over both long and short time periods. It was necessary to find such baseline vigilance tasks so that we could investigate both endogenous and exogenous influences on the occurrence of task-unrelated images and thoughts. Experiments 1 and 2 supported three potential baseline vigilance tasks. To follow are a number of studies which used at least one of the baseline tasks or a variant thereof to test a number of hypotheses regarding the relationship of TUIT frequency to exogenous and endogenous influences. These studies further demonstrate that a method has been developed which provides a reliable and sensitive meter for the measurement of TUIT likelihood.

Giambra, Rosenberg, Kasper, Yee, and Sack (1988–1989)

In this paper we hypothesized that TUIT likelihood varied directly with changes in arousal and activation level as expressed in the circadian cycle. Using one of the baseline tasks (2-s interevent interval, 10% targets, 20-min task) we obtained spontaneous and deliberate P-TUIT frequency every 2 h for a 26-h period. The frequency of spontaneous P-TUITs was found to fit a simple 22.04-h period sinusoidal, see Fig. 2. Spontaneously occurring TUITs were found to be a periodic function of time of day. Furthermore, periods of greater and lesser spontaneous P-TUIT frequencies corresponded, in general, with periods of greater and less body temperature—body temperature usually is taken as an indicate of arousal and activation level.

Shaw and Giambra (1993)

Shaw and Giambra viewed spontaneous, unbidden TUITs as an uncontrolled switching of attention from external stimuli to the contents of consciousness and as an expression of poor inhibitory control. They hypothesized that the spontaneous P-TUIT frequency during a "boring" vigilance task of college students who were diagnosed as hyperactive, i.e., attention-deficit/hyperactive disorder, as children was greater than the spontaneous P-TUIT frequency of students who were not so diagnosed. College students were given a measure which may be used to indicate hyperactivity when they were children. Frequencies of deliberate and spontaneous P-TUITs were determined using a task similar to the two-TUIT tasks described in Experiment 2. A significant hyperactivity effect was found for spontaneous P-TUIT frequency, deliberate P-TUIT frequency, and for their sum. Figure 3 shows that adults who were hyperactive as children had considerably more frequent spontaneous P-TUITs than all other groups, even those who scored in the top quartile of the hyperactivity scale.

Giambra, Grodsky, Belongie, and Rosenberg (In press)

We again hypothesized that spontaneous TUIT likelihood was related to brain activation. Giambra, Rosenberg, Kasper, Yee, and Sack (1988–1989) had provided evidence of a circadian rhythm in TUIT likelihood which appeared to be

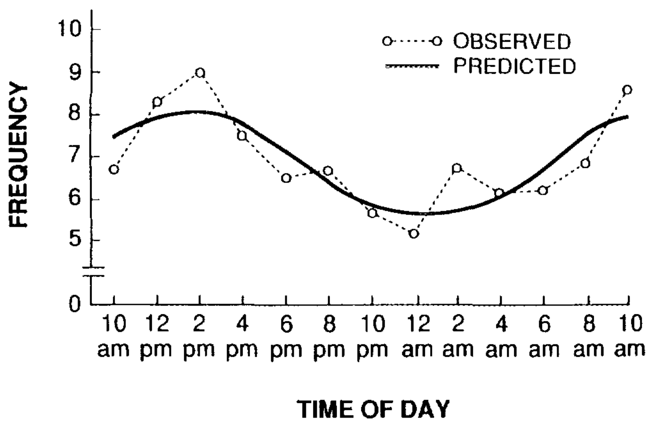

FIG. 2. The frequency of P-TUITs as a function of time of day (Giambra, Rosenberg, Kasper, Yee, & Sack, 1988–1989).

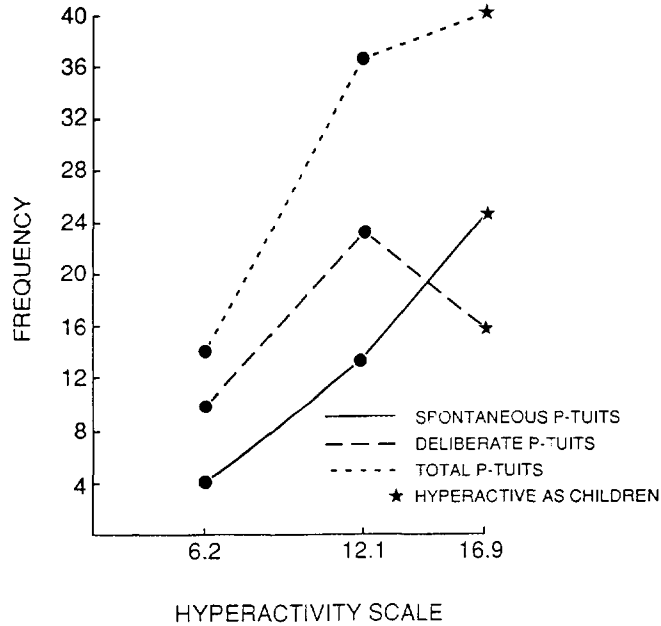

FIG. 3. The frequency of P-TUITs in adults who were and were not diagnosed as hyperactive as children (Shaw and Giambra, 1993).

coincident with the circadian rhythm of physiological and cortical arousal. Among the symptoms of depression are psychomotor retardation and a slowdown of thinking. Many individuals who have pathological depressive affect are also anxious and agitated, with concomitant increases in activation and arousal. Activation and arousal were determined by self-report using the Profile of Mood States (McNair, Lorr, & Dopplemen, 1971). In particular, we expected the frequency of unintentional TUITs to vary directly with the Vigor–Activity and Muscular Tension–Anxiety scales and inversely with the Depression–Dejection and Fatigue–Inertia scales. It has been reported that depressive individuals engage in less effortful thinking than nondepressed controls. We hypothesized that the likelihood of deliberate TUITs decreased with increased depressive level because deliberate TUITs may be viewed as effortful. Ten pathologically depressed individuals who did not have any other Axis I disorder and who were without a concurrent drug or alcohol addiction, who did not have electroconvulsive therapy within 6 months, and who had no history of brain damage or mental retardation performed the two-TUIT task (30% targets, 2-s interevent interval) for 21 min. We found significant correlations consistent with the hypotheses.

Grodsky and Giambra (1989, 1990–1991)

Reliable measurement of TUIT frequency has been demonstrated when the primary or ostensive task was an uninteresting and unchallenging vigilance task. Grodsky and Giambra (1990–1991) and Giambra and Grodsky (1989) showed that we can reliably measure TUIT frequency with a more cognitively demanding task, reading. Most common reading tasks are more resource demanding than the vigilance tasks used in Experiments 1 and 2. Furthermore, whatever the demand, reading probably always involves a greater depth of processing. Grodsky and Giambra (1990–1991) had subjects read four passages which were at two levels of interest and two levels of difficulty and undertake four vigilance tasks which putatively were also at two levels of interest and two levels of difficulty. Subjects indicated when a TUIT ended and whether the TUIT was deliberate or spontaneous for TUIT frequency, correlations between the reading and the vigilance tasks gave us an indication of how individual differences in TUIT likelihood during a shallow processing task like vigilance is maintained during a deep processing task like reading. TUIT frequency in the vigilance tasks was significantly correlated with TUIT frequency in the reading tasks, r's $> .50$. In addition, the more demanding reading task yielded fewer spontaneous or deliberate TUITs than the less-demanding vigilance tasks. Interest had no effect on TUITs. Greater difficulty resulted in fewer TUITs in the vigilance task only. In a separate study which examined the influence of text interest and difficulty on TUIT frequency, Giambra and Grodsky (1989) found significantly fewer TUITs for high interest passages than for low interest passages; passage difficulty again did not have a significant effect on TUIT frequency.

Some Additional Uses of TUIT Measurement

The TUIT measurement paradigm provides a laboratory method for looking at the products as well as the process of covert mental processing. In the study of problem solving the TUIT measurement paradigm could be used as an intermediate task to document the extent to which ideas about the problem continue to be processed [incubation] or generated [illumination] prior to a final attempt to solve the problem. Another use for this paradigm would be in an examination of the influence of mental disease and other putative thought dysfunctional syndromes on thought fluency and content. For example, the TUIT measurement method could be used to count the frequency of repetitive, obsessional thoughts. With this paradigm we can examine any thought production variation that results from physical illness and from changes in physical conditioning. We can also examine the influence on thought of the complete host of drugs, medicinal and recreational, that are routinely ingested today. Thought intrusions about taking a drug or drug-related behavior could be counted and used as an indication of the strength of an individual's addiction to a drug, especially in cases where the individual is attempting to break his or her addiction (see, for example, Gawin, 1991). Minimally, this paradigm can be used to quantify and precisely document what might be an important, but overlooked, individual difference variable, thought fecundity and fluidity.

Dual task paradigms have been used as an indication of the amount of resources used by the primary task. Changes in responses to the secondary task have been taken as indicative of the resources needed by various primary tasks or changes in conditions of the primary task. We, as well as Antrobus (1968), have shown that the frequency of task-unrelated images and thoughts is sensitive to the resources demanded by signal detection. Because TUITs occur as a natural event and their likelihood is influenced directly by the demands of an ongoing task, one could count TUITs to determine resource utilization by the primary task. Such reporting of TUITs would be minimally interfering with the primary task and is potentially superior to the use of any explicit secondary task.

Uncontrolled or spontaneous attention switching from external stimuli to the contents of consciousness has been essentially ignored in cognitive psychology. We have little information on what part such spontaneous attention switching plays in such common cognitive tasks as reading, learning, driving, listening, searching, and in the preparation and enactment of action sequences. Can training delay or stop such spontaneous attention switching? Is such attention switching in boring situations a biological useful intermediary to falling asleep? How much control do we have after the switch is made, i.e., can we immediately switch back to our prior focus of attention? Furthermore, we are only dimly aware or concerned with how biological limitations, such as sensory impairment (blindness, deafness) or super sensitivity, may increase such spontaneous attention switching or how this may impair or change both day-to-day and special purpose activities and functioning.

Finally, this method for recording spontaneous and deliberate TUIT frequency can, like any experimental method, be improved. An important improvement would be by more accurately recording when TUITs are occurring. One attempt to more accurately record the occurrence of TUITs was by training individuals to indicate when a TUIT begins without altering the continuation of that TUIT. We found, with one individual, that extensive practice reduced greatly the termination of a TUIT when it was reported as beginning. The probe method is potentially biased to underreporting because the subject may fail to respond as a result of being too absorbed in the primary task. This potential bias could be overcome by requiring a response when a TUIT has not occurred. Failures to respond could then be taken as an indication of the unreliability of the TUIT frequency count.

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