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External control of the stream of consciousness: Stimulus-based effects on involuntary thought sequences

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ABSTRACT

The stream of consciousness often appears whimsical and free from external control. Recent advances, however, reveal that the stream is more susceptible to external influence than previously assumed. Thoughts can be triggered by external stimuli in a manner that is involuntary, systematic, and nontrivial. Based on these advances, our experimental manipulation systematically triggered a sequence of, not one, but two involuntary thoughts. Participants were instructed to (a) not subvocalize the name of visual objects and (b) not count the number of letters comprising object names. On a substantial proportion of trials, participants experienced both kinds of involuntary thoughts. Each thought arose from distinct, high-level processes (naming versus counting). This is the first demonstration of the induction of two involuntary thoughts into the stream of consciousness. Stimulus word length influenced dependent measures systematically. Our findings are relevant to many fields associated with the study of consciousness, including attention, imagery, and action control.

1. Introduction

Conscious thoughts often seem free from external control and divorced from ongoing action and the current environment. For example, when performing a monotonous task at work, one may think, not only about the current task, but also about other activities (e.g., skiing). Such observations have led theorists to construe consciousness as a mercurial stream (James, 1890), one that is often 'offline' and insulated from the reins of the external world (Barron, Riby, Greer, & Smallwood, 2011; Fodor, 1975; Fodor, 1983; Smallwood & Schooler, 2006; Wegner & Bargh, 1998). These theoretical views are in accord with everyday intuitions regarding the unpredictable, autonomous, and 'free-willed' nature of conscious thought—a phenomenon that appears to operate unlike the workings of a machine.

Despite these intuitions and prevalent theoretical views, some theorists (e.g., Freud, 1938; James, 1890; Miller, N.E., 1959; Vygotsky, 1962; Wegner, 1989) have proposed that conscious thoughts are more predictable and more tied to external influence than what might appear to be the case at first glance (see review in Allen, Wilkins, Gazzaley, & Morsella, 2013). Helmholtz (1856), for example, noted that conscious thoughts can arise from 'unconscious inferences' in a manner that

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resembles reflexes. Helmholtz (1856) noted that these reflex-like, unconscious inferences are at play during high-level processes such as word reading—an automatic process that forces contents (phonological forms) into the stream of consciousness. Interestingly, one is conscious of the product of these sophisticated and unintentional processes, but not of the processes themselves (Lashley, 1956; Miller, G.A., 1962).

The stream of consciousness, despite its prevalence in everyday conversation, remains an understudied topic in experimental psychology. However, the topic is of interest to many subfields within the study of mind and brain, including consciousness, attention, self-regulation, psychopathology, mental imagery, and mind wandering.

1.1. The Reflexive Imagery Task

Building on these ideas (i.e., Freud, 1938; Helmholtz, 1856; James, 1890; Miller, N.E., 1959; Vygotsky, 1962; Wegner, 1989) and on the experimental approaches of Ach (1905), Wegner (1989), and Gollwitzer (1999), Allen et al. (2013) developed a new paradigm, the *Reflexive Imagery Task* (RIT), that allows one to begin to investigate how high-level conscious thoughts can be activated unintentionally and reliably through external stimuli. In the paradigm, participants are presented with pictures of objects after being instructed to not subvocalize (i.e., name in their minds but not aloud) the name of the objects. To convey the striking nature of this effect, we will present the reader with a demonstration of such an experimental situation. Momentarily, we will present to you an object enclosed within parentheses. Your task is to not subvocalize (i.e., 'say in one's head') the name of the object. Here is the stimulus (▲). The combination of these instructions (which induce a certain *action set*) and the presentation of the stimulus renders people incapable of suppressing the conscious experience of the phonological form of the word 'triangle' (Allen et al., 2013).

The conscious thoughts elicited in the RIT are 'high-level' because, in terms of stages of processing, they are post-perceptual and require complicated transformations, as in the case of object naming, which is a multi-stage process (Allen et al., 2013; Levelt, 1989). That the effect is involuntary diminishes the likelihood of experimental artifacts stemming from strategic processing, demand characteristics, or social desirability. (See Allen et al., 2013, p. 1320, for a list of other features that render the RIT a fruitful paradigm for the study of consciousness.) Neuroimaging evidence strongly suggests that, in paradigms in which participants must report the occurrence of conscious thoughts, it is unlikely that participants confabulate the occurrence of these internal experiences (Mason et al., 2007; McVay & Kane, 2010; Mitchell et al., 2007; Wyland, Kelley, Macrae, Gordon, & Heatherton, 2003).

1.2. The encapsulated nature of the generation of conscious contents

It has been proposed that, in circumstances such as those instantiated by the RIT, conscious thoughts arise unintentionally because of the 'encapsulated' nature of the generation of conscious content (Fodor, 1983; Krisst, Montemayor, & Morsella, in press). Such encapsulation is evident, not only in the Helmholtzian unconscious inferences that are at play in perceptual processing, but also in action control, as in the case of action-related urges. In certain stimulus environments, these urges (e.g., to inhale while holding one's breath while underwater) are triggered in a predictable and insuppressible manner. For example, when one holds one's breath while underwater, or runs barefoot across the hot desert sand in order to reach water, one cannot avoid the conscious inclinations to inhale or to avoid touching the hot sand, respectively (Morsella, 2005). The conscious urges triggered by the external world cannot be turned off voluntarily, even when the urges are maladaptive (Morsella, 2005; Öhman & Mineka, 2001). The action-related urges are encapsulated from voluntary control and externally-triggered. Thus, although inclinations triggered by external stimuli can be *behaviorally suppressed*, they often cannot be *mentally suppressed* (Bargh & Morsella, 2008).

2. The current approach: External control of the stream of consciousness

Together, theorizing from diverse sources (including evidence from classic perception research, the RIT, and research on the representation of urges and action options) reveals that conscious thoughts are less unpredictable and less shielded from external influence than is often appreciated. More importantly, these advances illuminate the kinds of mechanisms that give rise to the conscious contents comprising the stream of consciousness, a central, but understudied, phenomenon.

One limitation of past research (e.g., previous versions of the RIT) is that experimental manipulations could activate, by external influence, only one unintended thought. (As far as we know, no experimental manipulation has ever systematically elicited more than one involuntary thought.) However, in everyday life, the stream of consciousness usually involves more than one thought. Thus, in our experiment, we examined whether a single external stimulus could ever systematically trigger a sequence of *two* unintended thoughts in the stream of consciousness. Specifically, in our variant of the RIT, participants were presented with visual objects and instructed to (a) not subvocalize the name of the object (as in the basic RIT paradigm) and (b) not count the number of letters comprising the name of the object. This is the kind of incremental research, involving a robust, multifaceted, and reliable phenomenon that has been investigated for years, that is important for progress in the fields of psychological science and neuroscience (Nosek, Spies, & Motyl, 2012).

For the sake of illustration, we will present the reader with a demonstration of this experimental situation. Momentarily, we will present to you an object enclosed within parentheses. Your task is to not subvocalize the name of the object and, also, to not think of the number of letters comprising the object name. Here is the stimulus (). Some readers might experience the thoughts 'sun' and 'three'. The occurrence of both involuntary thoughts would be the first demonstration of the systematic activation of two involuntary thoughts in the stream of consciousness and would inform theories about the relationship between conscious and unconscious processes (e.g., unconscious inferences generating conscious contents). Importantly, the occurrence of both involuntary thoughts would reflect the involvement of two very different kinds of unintentional cognitive processes: *object naming* versus *object counting*. Each of these processes is quite sophisticated, high-level, and yields outputs (e.g., the phonological forms 'sun' and 'three') that are not direct reflections of external stimuli. In the case of object naming, for example, perceptual and conceptual–semantic processing of a stimulus (e.g., the picture of a house) must precede the activation of the phonological form (e.g., /haus/) of the object name (Levelt, 1989). The effect is very different in nature from that of passively hearing the words 'sun' and 'three', which, when heard, would naturally also influence the stream of consciousness in an unintentional manner.

In summary, in the present experiment, we examined whether two involuntary thoughts could be induced systematically into the stream of consciousness. In addition to investigating two different kinds of unintentional cognitive processes (naming versus counting), we also examined the effects of stimulus properties by dividing the objects in terms of their word length (three, five, and six or more letters). This provided us with a more nuanced analysis of potential unintentional effects, one in which unintentional processes might be more likely to occur for some word lengths (e.g., short words) than others (e.g., long words). Such a nuanced finding would suggest that the unintentional effects are unlikely to be artifacts of experimental demand.

Regarding the RIT, the entry of unintentional contents into the stream of consciousness is not fully understood (Wegner & Schneider, 2003). The event is based on several component processes (Allen et al., 2013). For example, as outlined in Allen et al. (2013), for the effect to arise, there is first the *induction of set* (e.g., to not subvocalize the name of visual objects). Second, the set must be held in memory during the time between the beginning of an experimental trial and the presentation of the object. During this delay, there may be what historically has been referred to as *imageless thought* (cf., Woodworth, 1915), in which action sets can influence ongoing behavioral dispositions even though these sets do not produce any detectable conscious contents. Third, there is the presentation of the triggering stimulus, which leads to the entry into consciousness of action-related imagery (e.g., subvocalization of the object name). The nature of entry into consciousness of any representation remains one of the greatest enigmas in psychological science (Crick & Koch, 2003).

If participants experience both forms of unintended thoughts (i.e., object names and number of letters), then this would be the first demonstration of external stimuli controlling a sequence of thoughts in the stream of consciousness.

2.2. Method

2.2.1. Participants

Thirty-six San Francisco State University students (M_{Age} = 19.90, *SD* = 3.14; female = 23) participated for course credit.

2.2.2. Stimuli and apparatus

All stimuli were presented on an Apple iMac computer monitor (50.8 cm) with a viewing distance of approximately 48 cm. Stimulus presentation was controlled by PsyScope software (Cohen, MacWhinney, Flatt, & Provost, 1993). Participants inputted responses by computer keyboard. The stimuli ($n = 52$) were black-and-white line drawings of well-known objects that yield high name agreement and that had been used successfully in previous research (Allen et al., 2013; Morsella & Miozzo, 2002; Snodgrass & Vanderwart, 1980). The stimuli were displayed in the center of the screen with subtended visual angles of $9.1° \times 7.6°$ degrees (7.6 cm $\times$ 6.4 cm).

Objects were divided based on the number of letters in the name: Short Names (three letters, $n = 20$), Medium Names (five letters, $n = 20$), and Long Names (six or more letters, $n = 12$) (Fig. 1, Appendix). The division of the three categories was based on the notion that Short Names had items with word lengths that could fall below the range of subitizing (a form of automatic counting (see Riggs et al., 2006)); Medium Names contained stimuli with word lengths that were at or near the boundary at which subitizing could occur; and Long Names contained visual objects whose names had word lengths that

Fig. 1. Sample stimuli from each word-length group.

were presumably above the subitizing range. However, it should be mentioned that there were only 12 Long Name items, whereas there were 20 of each of the other kinds of stimuli. The relatively low number of the Long Name stimuli reflects that we were constrained by the fact that the words had to have many letters, have been used successfully in previous studies, have high name agreement, and the possibility of being depicted as line drawings that were comparable to the other line drawings. One challenge we encountered when compiling the stimulus list for Long Names was that, for many long words (e.g., "laboratory"), there exists in everyday speech also a more economical, shorter word for the same referent (e.g., "lab").

See Table 1 for descriptive statistics concerning the word frequency (based on Kucera and Francis (1967) and on SUBTLEX$_{US}$ (Brysbaert & New, 2009)) of the names associated with our visual stimuli. With respect to both frequency indices, there was no significant difference in word frequency between items from Short Names and Long Names, $ts < 1.04$, $ps > .30$. An ANOVA including the Long Names stimuli (only 12 items), and using the Kucera-Francis Frequency count, revealed no significant difference in word frequency between the three word types, $F(2,48) = 1.78$, $p = .180$. However, when using the American Subtitles count, there was a significant difference in word frequency between Short Names and Long Names, $p = .021$. This difference was expected, as longer words tend to be lower in word frequency than shorter words (Levelt, 1989).

2.2.3. Procedures

Participants were first given instructions about mental imagery. Specifically, examples of mental imagery and what it means to have visual or auditory imagery were displayed on the screen and read aloud by the experimenter to the participant (instructions were taken from Jantz, Tomory, Gazzaley, & Morsella, 2013). Regarding visual imagery, participants read/heard, "*Take a moment to imagine what a tree looks like. Take a moment to imagine what a car looks like. You have just experienced an example of visual mental imagery*". Regarding auditory imagery, participants read/heard, "*Without saying it aloud, take a moment to imagine what the word 'HOUSE' sounds like. Take a moment to imagine what the word 'FLOWER' sounds like. You have just experienced an example of auditory mental imagery*".

In preparation for the critical trials, participants completed two training sessions. In the *Naming* training session, participants were instructed to press a key on the keyboard (character key z, covered with colored overlay) if they happened to think of the name of the object that was presented on the screen. Participants then completed 10 practice trials. For these trials, a fixation point (500 ms) and then a blank screen (500 ms) preceded the presentation of the image (4 s). While the image was presented, participants could indicate by pressing the 'z' key on the keyboard if they happened to think of the name of the object. In the *Letter Counting* training session, participants were instructed to press a different key on the keyboard (character key /, covered with a color that was different from that of the 'z' key) if they happened to think of the number of letters in the name of the object. Participants then completed 10 practice trials. The order of the presentation of the training sessions was counterbalanced so that half of the participants experienced the Naming training session first, and the other half experienced the Letter Counting training session first. Because the current version of the RIT requires that participants be capable of counting the number of letters comprising an object name (a task that involves a complicated form of response mapping), we had to make sure that participants were capable of performing this task and of monitoring whether they counted letters unintentionally. In addition, the training session provided the participant with the opportunity to practice pressing the correct button in order to indicate which kind of imagery was experienced, which was crucial for the subsequent, critical trials. The 'z' and '/' keys were chosen because they are on opposite sides of a standard keyboard, thereby minimizing participants' confusion, and because the location of the keys are equidistant in relation to the spacebar. The pairing of the two keys ('z' and '/') to naming and letter counting was fully counterbalanced across subjects.

After the training sessions, participants were informed that they would be shown a new series of images and were instructed, "*Try to NOT think of the NAME of the object. And try to NOT think of the NUMBER of letters in the name of the object*". Thus, for the critical trials, participants were instructed to NOT perform the tasks they had practiced in the brief training sessions. Participants were reminded to press the 'z' key if they happened to think of the name of the object and to press the '/' key if they happened to think of the number of letters in the name of the object. Participants were also informed that, if they happened to think of both the name of the object and the number of letters in the object name, they should indicate this by pressing both keys in the order in which the conscious imagery was experienced. It was emphasized to participants that they should respond as quickly as possible when they happened to think of the name of the object or to think of the number of letters. Participants were instructed to not respond in any way if they did not experience these two kinds of conscious imagery. Participants were instructed to keep their eyes focused on the center of the screen at all times. Critical trials ($n = 52$) were identical to practice trials except that participants indicated, while the image was displayed on the screen, if they happened to think of the name of the object and if they happened to think of the number of letters in the object name.

Table 1
Mean word frequency for object names as a function of word length group.

	3 Letters	5 Letters	6 or more letters
Kucera-Francis written frequency count	74.30 (93.82)	68.05 (134.44)	5.27 (5.73)
American English Subtitles (SUBTLEX$_{US}$)	102.48 (129.84)	61.63 (119.85)	6.32 (5.91)

Note: values in parentheses are *SD*s.

After each trial, participants inputted by keyboard the actual imagery they experienced (e.g., "CAT," for the name imagery, and "3," for counting imagery). Participants were instructed to input "NA" ("not applicable") if no imagery was experienced during the trial.

Once participants completed the experiment, they responded to a series of funneled debriefing questions (following the procedures of Bargh & Chartrand, 2000), which included general questions to assess whether participants (a) were aware of the purpose of the study, (b) had any strategies for completing the task, and (c) experienced anything that interfered with their performance on the task. Examination of the funneled debriefing data revealed that participants did not discern the hypothesis at hand.

The data from two participants were excluded from analysis. The data from one participant were excluded because the participant was not able to finish the study due to a programming error. The data from the other participant were excluded because the participant opted out of the study after training and therefore did not complete the critical trials.

3. Results

In this variant of the RIT, involuntary, stimulus-elicited conscious imagery arose on many trials (Table 2). The proportion of trials with involuntary subvocalizations of the object name was substantial ($M = .73$, $SE = .04$), a proportion that was significantly different from zero, $t(35) = 19.37$, $p < .001$. More surprisingly, on a substantial proportion of trials, participants reported involuntarily counting the number of letters comprising the object name ($M = .33$, $SE = .04$), a proportion that was significantly different from zero, $t(35) = 7.54$, $p < .001$. The proportion of trials with both kinds of imagery was .30 ($SE = .04$), a proportion that was significantly different from zero, $t(35) = 6.83$, $p < .001$.

The proportion of name imagery was significantly higher than that of counting, $t(35) = 9.21$, $p < .001$, $\eta_p^2 = .71$. This significant contrast between naming and counting imagery is also found with the arcsine transformations of the proportion data, $t(35) = 8.70$, $p < .001$. (Arcsine transformations are often used to statistically normalize data that are in the form of proportions.) The proportion of trials with no imagery was .24 ($SE = .04$).

3.1. Word length effects

As revealed in Fig. 2, the factor Word Length (Short, Medium, or Long) had an influence on imagery rates. Each of the means presented in Fig. 2 is significantly different from zero, $ts > 3.77$, $ps < .001$, and such is the case even when one collapses across the word-length conditions, $ts > 6.73$, $ps < .0001$. For both of these analyses, the same pattern of results was found with arcsine transformations of the proportion data.

An omnibus 2 × 3 ANOVA with imagery rate as a dependent measure and Stimulus Attribute (Name versus Number of Letters) and Word Length as within-subjects factors revealed a main effect of Stimulus Attribute, $F(1,35) = 91.37$, $p < .001$, $\eta_p^2 = .72$, a main effect of Word Length, $F(2,70) = 53.30$, $p < .001$, $\eta_p^2 = .60$, and an interaction between the two factors, $F(2,70) = 7.21$, $p = .001$, $\eta_p^2 = .17$. Planned contrasts revealed that each of the cells (presented as the bars in Fig. 2) is significantly different from each of the other cells, $ts > 2.60$, $ps < .011$. The same pattern of results arose with the arcsine transformations of the proportion data, in which there was a main effect of Stimulus Attribute, $F(1,35) = 86.91$, $p < .001$, a main effect of Word Length, $F(2,70) = 47.58$, $p < .001$, and an interaction between the two factors, $F(2,70) = 7.52$, $p = .001$. However, with the arcsine transforms, the contrast between Short (Name Attribute) and Medium (Name Attribute) was no longer significant, $p > .216$.

Although our experimental project was not designed with the purpose of yielding data that are amenable to regression analysis, to learn about the associations between our dependent measures and Stimulus Attributes (e.g., word length and word frequency), we conducted several exploratory regression analyses. A multiple regression analysis on arcsined imagery rates for unintentional object naming was performed with the categorical variable pertaining to word length (Low = 3 letters, Medium = 5 letters, Long = 6 or more letters) and the numeric variable of word frequency ($SUBTLEX_{US}$; Brysbaert & New, 2009 corpus). We found an overall effect of the model, $F(4,47) = 6.60$, $p < .001$, $R^2 = .305$. Specifically, word length was negatively correlated with imagery rates for the name of the object, $b^* = -.524$, $F(3,47) = 17.94$, $p < .001$, $r_{a(b.c)} = .484$. This means that increasing the number of letters in the object name was associated with less naming imagery. The variable for word frequency did not significantly predict imagery rates for the name of the object, $b^* = .153$, $F(1,47) = 2.66$, $p = .110$, $r_{a(c.b)} = .142$. This suggests that, for our measure (naming imagery), the variable Word Length accounts for more variance than the variable of Word Frequency.

Table 2
Mean proportions and latencies (ms) of unintentional imagery.

	Name imagery	Number imagery	Both	No imagery
Rates	.73 (.04)	.33 (.04)	.30 (.04)	.24 (.04)
Latency	1,745.97 (103.48)	2,110.67 (86.54)		

Note: values in parentheses are *SE*s.

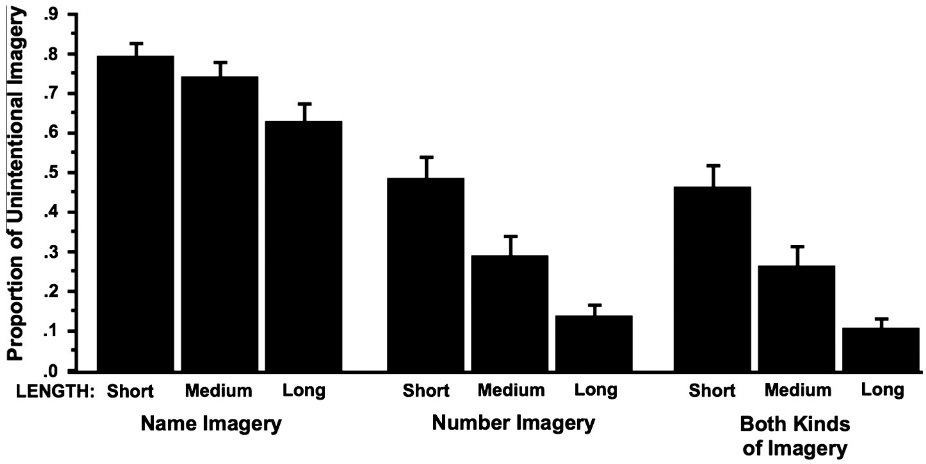

Fig. 2. Mean proportion of unintentional imagery as a function of Stimulus Attribute (object name and number of letters in object name). Error bars indicate *SEM*s.

In addition, we performed a multiple regression analysis on the arcsined imagery rates of *number of letters in the object name* with the variables Word Length and Word Frequency in the model. This analysis revealed an overall effect of the model, $F(4,47) = 36.41$, $p < .001$, $R^2 = .735$. Word length was negatively correlated with imagery rates for the number of letters in the object name, $b^* = -.834$, $F(3,47) = 146.10$, $p < .001$, $r_{a(b.c)} = .767$. This means that increasing the number of letters in the object name was associated with less imagery about the number of letters. Word Frequency did not significantly predict imagery rates for the number of letters, $b^* = .081$, $F(1,47) = 1.00$, $p = .322$, $r_{a(c.b)} = .074$.

3.2. Latency effects

On average, the name imagery arose earlier in the trial than the number imagery (difference in means = 364.70 ms), $t(35) = 4.67$, $p < .001$, $\eta_p^2 = .41$. The mean proportion of trials in which the name imagery preceded the number imagery was .90 ($SD = .18$). The latency effects associated with Word Length were more systematic than anticipated and require further investigation: An omnibus ANOVA with imagery latency as a dependent measure and Stimulus Attribute (Name versus Number of Letters) and Word Length as within-subjects factors revealed a main effect of Stimulus Attribute, $F(1,35) = 16.84$, $p < .001$, $\eta_p^2 = .47$, a main effect of Word Length, $F(2,70) = 4.12$, $p = .024$, $\eta_p^2 = .18$, and no interaction between the two factors, $F(2,70) = 1.60$, $p = .216$, $\eta_p^2 = .08$. For name imagery, $M_{Short} = 1{,}641.57$ ($SE = 100.33$), $M_{Medium} = 1{,}769.92$ ($SE = 109.29$), and $M_{Long} = 1{,}942.32$ ($SE = 120.44$); for number imagery, $M_{Short} = 1{,}967.66$ ($SE = 96.08$), $M_{Medium} = 2{,}399.21$ ($SE = 130.17$), and $M_{Long} = 2{,}174.03$ ($SE = 136.75$).

We performed a multiple regression analysis on the speed at which imagery of the name of the object entered into consciousness with the variables Word Length and Word Frequency entered into the model. This analysis revealed an overall effect of the model, $F(4,47) = 4.34$, $p = .005$, $R^2 = .207$. Word Length was positively correlated with the latency of imagery for the object name, $b^* = .474$, $F(3,47) = 13.84$, $p < .001$, $r_{a(b.c)} = .437$. This means that increasing the number of letters in the object name was associated with slower latencies for entry into consciousness of the object name. Word Frequency did not significantly predict the latency of the name of the object, $b^* = -.097$, $F(1,47) = 0.28$, $p = .596$, $r_{a(c.b)} = .089$.

Last, we performed a multiple regression analysis on the speed at which imagery of the number of letters entered into consciousness with the variables Word Length and Word Frequency entered into the model. This analysis showed an overall effect of the model, $F(4,47) = 8.62$, $p = .001$, $R^2 = .230$. Word Length was positively correlated with the latency of imagery for the number of letters, $b^* = .484$, $F(3,47) = 6.10$, $p = .017$, $r_{a(b.c)} = .453$. This means that increasing the number of letters in the object name was associated with slower latencies for entry into consciousness of the number of letters. In contrast, Word Frequency did not significantly predict the latency of imagery for the number of letters, $b^* = -.063$, $F(1,47) = 0.21$, $p = .647$, $r_{a(c.b)} = .057$.

4. Discussion

The thoughts comprising the stream of consciousness often appear to be insulated from the influence of the external world. However, past theorizing and recent experimentation (e.g., Allen et al., 2013) reveals that such thoughts can be triggered into existence by external stimuli in a manner that is nontrivial, principled, reliable, and systematic. Our experiment builds on this past research by revealing how action sets can, when combined with certain forms of environmental stimulation, trigger not only the occurrence of a single conscious thought, but a sequence of two thoughts in the stream of consciousness.

Our experiment further elucidates the interplay that exists in the stream of consciousness between two related involuntary thoughts of very different content, that is, the name of an object and the number of letters in that object name. It is important to underscore that our study provides the first demonstration that a sequence of involuntary thoughts, with one thought following the other, can be instantiated through a form of external influence. Involuntary subvocalizations of object names arose on roughly 70% of the trials. Strikingly, involuntary letter counting arose on roughly one-third of the trials. When the word was a short word, involuntary letter counting occurred on roughly 50% of the trials. On 30% of the trials, participants experienced both forms of unintended thought.

Our paradigm affords one the possibility of examining when these conscious thoughts arise. This feature of our paradigm revealed that the mean latency of unintentional subvocalizing is shorter than that of unintentional counting. That imagery rates and imagery latencies were influenced differentially by the factor of Word Length supports the view that participants' reports are not simply the result of experimental demand or high-level strategic processes. This pattern of results requires further investigation and may reflect that automatic counting ('subitizing') is more likely to occur for words with shorter lengths. It is important to note that subitizing, as a process, is far from straightforward and far from uncontroversial. There is some doubt regarding whether (a) different mechanisms are at play in the counting of small quantities versus that of larger quantities, or (b) different latency slopes exist for the counting of small versus large numbers of items (see Riggs et al., 2006).

The RIT phenomenon, in which thoughts enter consciousness unintentionally, is a rich phenomenon that can be mined experimentally in many ways. At this stage of understanding, we will not pretend to understand all aspects of what occurs in this task, a task that involves the involuntary entry of high-level contents into consciousness (see discussion in Allen et al., 2013). For an investigation regarding the occurrence of conscious thoughts, it is impossible to avoid the technique of self-report and its well-known limitations. For example, self-reports can be inaccurate as a result of participants basing their responses on heuristics or on a strategy of how to comport oneself during an experiment (see discussion in Morsella et al. (2009)). In addition, inaccurate memory of fleeting mental contents can lead to incorrect self-reports (Block, 2007). Given the striking robustness and reliability of the RIT phenomenon (as perhaps experienced by the reader in response to our examples of the triangle and sun), we do not believe that these well known limitations undermine the validity of our primary findings.

Future research can examine the role that the variable of word frequency may have on the RIT effect. When designing this study and compiling the stimulus lists, we strove to minimize any potential effects from this variable. Our regression analyses support the interpretation that word length accounted for more variance than did word frequency. However, we cannot rule out an influence of word frequency in our results, as word frequency and word length are known to be correlated with each other (Levelt, 1989). In addition, future research could investigate whether, in the RIT, more than two thoughts can be elicited through external control and whether processes that are more complex than object naming or letter counting could, too, transpire unintentionally. Future investigations may also examine whether comparable effects are obtained when, at the beginning of the session, there is no form of training or when the stimulus set includes a greater number of visual objects having long word lengths. Such future studies could also investigate the neural correlates of the various events involved in our task. It is our hope that our experiment will serve as a foundation for research enterprises that will illuminate a range of psychological phenomena. Our findings and tasks focus on component processes that are of interest in disparate subfields of the study of mind and brain, including consciousness, attention, decision making, cognitive control, imagery, and action control. More generally, our experimental approach reveals that the stream of consciousness, one of the greatest mysteries in science (Crick & Koch, 2003), can be studied experimentally.

Acknowledgments

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Appendix A

List of the visual objects (line drawings)

3 Letters	5 Letters	6 or more letters
Cow	Apple	Alligator
Tie	Brain	Artichoke
Pig	Couch	Bicycle
Box	Sheep	Butterfly
Key	Radio	Helicopter

(*continued on next page*)

Appendix A (*continued*)

List of the visual objects (line drawings)		
3 Letters	5 Letters	6 or more letters
Sun	Clown	Pineapple
Cat	Heart	Turtle
Fly	Screw	Watermelon
Saw	Chain	Rhinoceros
Car	House	Scissors
Dog	Brush	Suitcase
Ear	Crown	Windmill
Eye	Horse	
Jug	Ruler	
Bow	Snail	
Owl	Stool	
Fox	Sword	
Rat	Towel	
Pen	Tower	
Gun	Wheel	

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