Forms of Mindwandering & Access to Meta Consciousness

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Introduction

As you are reading this report, you will probably experience episodes of mindwandering. A word, a sentence, or even an intrusive thought will make your mind suddenly drift and think about something other than these very words. You may stop to read for a moment, discard your report-unrelated thought and start reading again. You may also continue to read, without discarding your report-unrelated thoughts and notice a few seconds or minutes later that you have not understood a thing of the paragraph, because you were thinking about off-task content.

The disrupting thoughts have numerous names: spontaneous cognitions (Antrobus et al., 1966; Christoff et al., 2006), mindwandering episodes (Smallwood & Schooler, 2006; Schooler et al., 2011; Gruberger et al. 2011), daydreams (Klinger, 2009; Mar, 2012), task-unrelated thoughts (Smallwood et al. 2004) and stimulus independent thoughts (Teasdale et al. 1995, Mason et al. 2007).

Some distinctions have been drawn between these terms (Stawarczyk et al., 2011, Mar et al., 2012), but they all share the majority of their properties. All decrease performance on the task at hand (failures in vigilance task (Smallwood & Schooler, 2006) and comprehension task (Smallwood et al. 2008) for example). Most of them are related to bad mood and unhappiness (Smallwood et al., 2005; Killingsworth & Gilbert, 2010; Mason et al. 2012) and to activations in the default network of the brain (Stawarczyk et al. 2011b, Christoff et al., 2009, Mason et al. 2007).

A crucial distinction has been drawn amongst all of these various reports: the distinction between mindwandering with meta-awareness (also coined “meta-consciousness”, Schooler, 2002) and mindwandering without meta-awareness. Meta-awareness is the knowledge that one is currently full access to the description, interpretation and characterization of the state of mind (Schooler, 2002). According to Schooler (2002), conscious representations are all “experienced” and therefore available to the subject’s introspection. However, only some of them are re-represented, that is to say meta-aware. Precisely, the moment conscious experiences are accessed may differ, depending on how meta-aware the subject is of his own thoughts.

When one is experiencing (i.e. having an episode of) mind-wandering, one may be meta-aware of it, that is to say know it, and potentially act with or on it – report it, attempt to stop it or control it. This meta-aware mindwandering has been termed “tuning out” (Smallwood & Schooler, 2006). However, one may not be meta-aware of his experience of mindwandering (termed “zoning out”), and not notice it, or realize after a few seconds or minutes. Zoning out is what allows the reader to reach the end of the paragraph without comprehension. This distinction is crucial because it goes against the intuition that one has a direct and permanent access to one’s thoughts through introspection. In fact, one may lack noticing that one is not focused on the task at hand anymore – on a wide range of tasks from reading to driving or listening to a talk; almost every activity of daily life (Killingsworth & Gilbert, 2011).

Traditionally, the data concerning meta-awareness of mindwandering has been extracted using two main tools. First, participants are often required to spontaneously report their off-task thoughts and therefore, given that participant reports are by definition meta-aware, these spontaneous reports (or “self-caught off-task episodes”) allow the “tuning out” episode count (Schooler, Reichle & Halpern, 2004). Second, participants can also be asked at random intervals to classify their thoughts (these questions being called “thought-probes”, Klinger, 1978, Hurlburt & Heavey, 2004), and this includes questions as to whether they were on-task
or off-task, or questions as to whether they were meta-aware or not of being off-task. Off-task episodes using this protocol are therefore “probe-caught”.

Using combinations of these tools, experimental manipulations have shown that the proportion of mindwandering tends to increase while the proportion of meta-awareness decreases. (Sayette et al. 2009, 2010).

However, though notions of mindwandering and meta-awareness are established in the literature (Schooler et al. 2011), there is still little known about the very differences between tuning out and zoning out. Cheyne et al. (2009) have proposed an attentional model suggesting that zoning out is a further step in disengagement from the task compared to tuning out. Other evidence suggests that zoning out should not be considered equivalent to tuning out without awareness, but on the contrary, tuning out is zoning out that suddenly gain awareness through processes involved in the detection of saliency (Hasenkamp et al. 2012). Our proposal complements these two views, suggesting phenomenological differences between tuning out and zoning out.

In fact, meta-awareness echoes to the notion of self-awareness, or the “capacity to become the object of one’s own attention, where the individual actively identifies, processes, and stores information about the self” (Morin & Everett, 1990). Two kinds of information about the self can be distinguished: information about one’s own mental states and information about one’s own public self-characteristics (Morin, 2005). Information about one’s own mental states gives the notion that self-awareness encompasses the notion of meta-awareness. Morin (2005) has therefore made the parallel between his concept of self-awareness (about one’s own mental states) and Schooler’s concept of meta-consciousness (of the contents of one’s consciousness).

Yet, a body of research sustains the hypothesis that phenomenological aspects of thoughts, such as inner speech (equivalent throughout this report to “verbal thoughts”), would be “one of the cognitive tools the self uses in acquiring and processing information about itself” (Morin & Everett, 1990). Morin (2005) adds some evidence to this hypothesis. First, “portions of the left prefrontal lobe are both associated with self-reflective activities and inner speech”. Second, “loss of inner speech following brain damage leads to self-awareness deficits”. Third, “independent studies using various measures of self-talk and self-awareness support the hypothesis of a correlation between these two mental activities” and suggest that “the more one focuses on the self the more one talks to oneself (about private self-aspects), and vice-versa”.

This particular relation drawn between self-awareness and inner speech led us to hypothesize a similar relation between meta-awareness and inner speech, and to test it among the phenomenon of zoning out and tuning out. This hypothesis is precisely that inner speech is related to meta-awareness of off-task cognitions.

The very domain of mindwandering would also lead to a similar prediction. The few phenomenological accounts of mindwandering state that on one side mindwandering is mostly not meta-aware (and that is the common idea we have of it, of someone “lost in his thoughts”), and on the other side “Task Unrelated Thought” would be “similar in many respects to dynamic [mental] imagery” (Smallwood et al. 2004). These two separated statements led us to complete our hypothesis and state that not only mindwandering would be phenomenologically similar to mental imagery (adding evidence to Smallwood’s hypothesis), but also that there would be an inverse relation between mental imagery and the very meta-awareness of mindwandering.
In order to test this double hypothesis, we attempted to manipulate proportions of verbal and imaginal thoughts in four experiments. Two experiments were implicit inductions of inner speech and mental imagery (Experiment 2 and 3) and two experiments were suppressions of inner speech and mental imagery (Experiment 1 and 4). To our knowledge, such manipulations of forms in the context of mindwandering had never been done before.

These experiments allowed testing for the causality of inner speech on meta-awareness of mindwandering thoughts. In fact, according to our hypothesis, manipulations that suppress inner speech also decrease meta-awareness, and manipulations that induce inner speech also increase meta-awareness (of mindwandering). Given the absence in the literature of the hypothesis that mental imagery would have any causal relation to meta-awareness (or even self-awareness) and the fact that according to Baddeley & Hitch (1974) model of working memory, the phonological loop supporting inner speech and the visuospatial sketchpad supporting mental imagery are separated and can act together, we simply stated a inverse relation between meta-awareness of mindwandering and mental imagery.

Finally, given that evidence has been recently brought that participants’ reports of their phenomenology is likely to be consistent with their brain activations in fMRI, or, in other words, that introspection of phenomenology could be reliable (Christoff, 2011, unpublished data¹), each thought probe or spontaneous report included questions about the phenomenology participants were experiencing, regardless of being on or off task, meta-aware or not.

We anticipated these reports to confirm our manipulation of inner speech and mental imagery, and hence to mediate the effect of the manipulation on meta-awareness.

¹ This citation comes from Pr. Kalina Christoff’s talk on “Spontaneous thought processes” the 7/8/2011 at the 2011 Summer Institute in Cognitive Neuroscience at the University of California Santa Barbara. Participants were 7 Vipassana medidators – meditation supposed to enhance introspection
General Method

Four experiments were conducted in order to test these hypotheses. All were designed to manipulate the proportion of inner speech and measure the corresponding proportion of meta-awareness. We worked in the framework of Baddeley & Hitch (1974; Baddeley, 1992) theory of Working Memory because it accounts for the existence of inner speech (through the use of the phonological loop) and of mental imagery (through the use of the visuospatial sketchpad). Experiments 2, 3 and 4 were also based on the notion of cognitive style (Paivio, 1971), proposing that on daily life, human beings preferentially use inner speech or mental imagery when thinking.

All experiments had a go/no-go task as a main task, and more precisely Experiment 1, 3 and 4 were edited versions of a go/no-go task widely used to study mindwandering: the Sustained Attention to Response Task (referred below as SART, Robertson et al. 1997). In fact, clear behavioral markers of mindwandering have been identified in the SART (Cheyne et al., 2009).

To the go/no-go main task was always random (Experiment 1 and 2) or pseudo-random (Experiment 3 and 4) thought-probes that interrupt the task. The computer screen displayed questions about the participant’s “last thought” (the conscious experience he had just prior to the probe), such as whether he was on-task or off-task or what the form of his thought was like. Depending on the experiment and on questions, the subject answered on Likert scales (Experiment 1 and 2), forced-choice or non-exclusive answer (Experiment 1).

Finally, participants in experiments 1 and 4 could spontaneously report their off-task thoughts. When doing so, they were asked about the form and time-orientation (past-, present-, future-oriented or not time-oriented thoughts). Although time orientation of the last thought was asked for experiments 1, 2 and 3, we will only present data concerning mindwandering, meta-awareness and phenomenology (form of thoughts).

Overview of the Experiments

Using this general method, Experiments 1 and 4 more precisely aimed at suppressing or interfering with inner speech (respectively with articulatory suppression and irrelevant sound effect). Experiment 4 also aimed at interfering with mental imagery (with visual noise) and testing whether the modality of the SART (visual numbers on the screen or auditory numbers through earphones) had any effect on meta-awareness too.

On the contrary, Experiments 2 and 3 aimed at inducing either inner speech (respectively with presenting prominently words as stimuli instead of pictures and with using stereotype threat manipulation) or mental imagery (respectively with presenting prominently pictures as stimuli instead of words and with using public speaking threat manipulation).

All experiments were within-participants designs, except for Experiment 3 (using Stereotype threat and Public Speaking threat, which was a between-participants design).
Experiment 1

Experiment 1 used articulatory suppression as a classical means to interfere with verbal working memory (Baddeley, 1992). Inspired by Emerson & Miyake (2003), three conditions based on a dual task paradigm were applied to a Sustained Attention to Response Task (SART). Performing the sole SART constituted a first control (single-) task. Participants also performed two dual tasks: the SART with a foot tapping task (a second control (dual-) task) and the SART with an articulatory suppression task (the experimental dual-task). Participants were hypothesized to report less inner speech and more importantly, less meta-aware mindwandering in the articulatory suppression task than in both of the control tasks.

Methods

Participants: 29 students from the listing of the Department of Psychology of the University of California, Santa Barbara (UCSB) volunteered to participate in the study. 4 were excluded for noncompliance to the instructions of dual task. Of the remaining 25 participants, 15 were women, and participants’ age ranged from 18 to 39 years (M=21.5, SD=4.4). All participants had normal or corrected to normal vision and spoke fluent English. Each participant performed in the six different blocks constituting the three conditions (two blocks by condition).

Materials

Instructions – The experiment was presented as a test of the participant’s ability to keep a rhythm while doing an attention task (SART and introspection of his thoughts). Each participant was audio recorded during the entire experiment. This instruction and the recording were incentives to correctly perform the dual tasks as well as a check for compliance with instructions.

SART – A version of the SART (Robertson et al. 1997) was used as main task. Stimuli (numbers between 0 and 9) were presented sequentially in white font at the center of a black computer screen (refresh rate of 60Hz). Participants were asked to press the spacebar as fast and accurately as possible to the numbers and to withhold the response when presented with the number 3 (the target stimulus). The inter-stimulus interval was 1500ms, and the duration of each stimulus (target and non-targets) was 500ms.

The experiment was divided into six blocks (two blocks per condition, explained below) of 108 trials (8 no-go trials (7%) which position was fully randomized among the 100 go trials). For each participant, the blocks order was pseudo-randomized so that two blocks of the same condition could not directly follow each other.

Dual task – Deriving from Emerson & Miyake (2003), each participant went through three conditions: (1) a single-task (performing the SART), (2) a foot tapping and (3) an articulatory suppression condition. The foot tapping condition required to tap on a stapler set on the floor while doing the SART. The articulatory suppression condition required to say “a-b-c” out loud. The rhythm for both AS and FT conditions was one beat every 750ms and a metronome was set at the beginning of each part such that the participants could get the “right rhythm”. The metronome was shut down as soon as they judged their rhythm correct enough.
Thought-reports - The self-catching / probe-catching paradigm (Smallwood & Schooler, 2006; Schooler, 2011) was used to collect thought-reports via a computer.

Inspiring by Sayette et al. (2009), participants were required to press “Enter” on the keyboard to spontaneously report off-task thoughts every time they noticed they had one, at any time of the experiment. These trials were renamed “selfcaught” trials and removed from the go/no-go classification. Moreover, four external thought-probes were also randomly distributed into each of the six blocks and allowed assessment of overall mindwandering.

Both spontaneous and external thought reports interrupted the dual task: participants no longer did the SART or the articulatory suppression or foot tapping tasks. The metronome was set again at the end of each probe to get the rhythm back.

Deriving from Christoff et al. (2009), when randomly thought probed participants were first asked the extent to which they were on-task or not just prior to the probe using a 5-point Likert scale ranging from 1: “On-Task” to 5: “Off-Task”. Off-Task was explicitly related to daydreaming and mind-wandering.

Participants were secondly asked about their meta-awareness of their last thought on a 5-point Likert scale ranging from 1: “Aware” to 5: “Unaware”. Unawareness was exemplified on the off-task side with mindless reading (“zoning out”), and on the on-task side as really deep focus. The aware side was supposed to be under-represented as participants were explicitly told that if they were aware of a mindwandering episode, they should spontaneously report it.

As a consequence, these two questions were absent from spontaneous reports that were by default off-task and aware.

However, for all reports, participants were asked about the “form” (phenomenology) of their last thought. Three possibilities were provided: (1) Inner Speech: i.e. talking to him/herself using words that he/she would have been able to report if needed (e.g. on-task: verbal feedback on performance, e.g. off task: verbally wondering what an acquaintance was currently doing), (2) Imagery: i.e. having the visual experience of a mental image or a “movie-like” memory (e.g. on-task: mentally superimposing the target number on the real numbers and see if they match, e.g. off-task: having visual remembrance of the people in a party, like a group photo), (3) Else: using neither of inner speech or imagery to think, failing to introspect phenomenology, having strong doubts. This question of phenomenology, unlike the two others, did not call for only one answer and participants could report mixed forms of thought (even with the Else form if they felt that it was “imagery-inner speech, plus something”).

Participants were finally asked about the time orientation of their last thought. Four possible choices were provided: (1) Past-oriented thought, such as thinking about a recent mistake (on-task thought) or one’s breakfast (off-task thought). (2) Present-oriented thought, such as concurrent monitoring of one’s own performance (on-task thought) or wonders about acquaintances’ current activities (off-task thought). (3) Future-oriented thought, such as anticipation of the coming numbers (on-task thought) or one’s dinner (off-task thought). (4) Not-time-oriented thought: inability to tell the time orientation of one’s thought or the thought had no time orientation (e.g. thinking about mathematic principles).

Each questions allowed participants to avoid committing themselves in case of acknowledged failure in introspection: they could answer at the middle of the On-Off-Task and Aware-Unaware scales and report “Else” form and “Not-time-oriented” thought, so that other responses could be given with some confidence.

Procedure: Participants were tested individually in a quiet, well-lit room. Instructions were given orally by the experimenter based on what was written on the computer screen and available to the reading of the participant. Then, participants went through three training sessions of 24 items each corresponding to the three conditions (in random order). The
experimenter made sure participants had understood the go/no-go task and were correctly performing the articulatory suppression and foot tapping tasks. He also further explained and corrected thought-probes mistakes; using questions participants should ask themselves (e.g. “You report you just had a verbal thought, would you be able if needed to tell the precise words involved in this thought?”). The experimenter left before the experimental session started.

The sum of the six blocks constituting the experimental session lasted from 20 to 40 minutes (mean=29, SD=3) and depended mainly on the duration of participants’ preparation for each block (metronome adjustment) and on their ability to easily classify their thoughts.

Once finished, the participant was debriefed, paid 10 USD or given course credits and thanked.

Predictions: Participants were predicted less meta-awareness in their mindwandering in the articulatory suppression condition than in both of the control conditions. This lack of meta-awareness could be expressed in two ways.

Introspectively, it corresponds to a decrease in the number of self-caught mindwandering with no concurrent diminution of overall mindwandering assessed with random probes (Sayette et al. 2009).

Psychophysically, it corresponds to indirect markers of mindwandering obtained with the SART, such as the number of no-go errors (SART errors), the number of go errors (omissions), but also the variability of Response Times (RT) or Response Times that were too fast to be appropriated responses (Cheyne et al. 2009, Mrazek et al. 2012). Of particular interest to our study, high Response Time Coefficient of Variability (RT CV: standard deviation of correct go-RT / mean of correct go-RT) has been related to a state 1 of disengagement from the task (Cheyne et al., 2009), that is to say to “tuning out” (mindwandering with meta-awareness). Also, numerous anticipations (RT < 200ms, regardless of go or no-go trials) have been related to a state 2 of disengagement that is to say to “zoning out” (mindwandering without awareness).

Results

All data was analyzed using R (R Development Core Team, 2009) and the R packages lme4 (Bates & Maechler, 2009). Throughout the report, we present p-values that are considered significant at the α=0.05 level. Analyses were conducted on the 25 participants that complied with the dual task.

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<th>SART and indirect measures of mindwandering</th>
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Firstly, we examined the effects of articulatory suppression on RT CV and anticipations of the SART-data.

To this end, we conducted a one-way within participants ANOVA with condition as factor (3 modalities: single-task, articulatory suppression, foot tapping) on RT CV. It revealed a main effect of condition (F(2,48)=9.6, p<.001). Follow-up post hoc tests indicated that RT CV in the single-task (0.26) were significantly lower than in both the Articulatory suppression (0.32, F(1, 24)=10.1, p<.01) and the Foot tapping conditions (0.33, F(1, 24)=12.8, p<.01). The difference between articulatory suppression and foot tapping did not reached significance (p>.3).

A similar one-way ANOVA on anticipations revealed a main effect of condition (F(2,48)=5.4, p<.01). Follow-up post hoc tests indicated that the number of anticipations in the single-task
(0.76) was significantly less than in both the Articulatory suppression (2.76, F(1, 24)=8.9, p<.01) and the Foot tapping conditions (2.40, F(1, 24)=6.2, p<.05). The difference between articulatory suppression and foot tapping did not reached significance (p>.5).

This pattern of result indicates that overall mindwandering (state 1 and 2) tended to be higher in both the articulatory suppression and the foot tapping conditions compared to the single task. This partially confirms our predictions that zoning out was increased in the articulatory suppression compared to the single-task. However, given that no significant difference was found between the two dual tasks, we cannot exclude the possibility that this is a dual task effect.

**Thought-reports**

Secondly, we examined the effects of articulatory suppression on the reported mindwandering (external thought-probes only), on the reported forms (overall thoughts reports) and on the reported meta-awareness of mindwandering (self-caught mindwandering only).²

To this end, we computed three binomial variables among the total of the 646 thought-probes and 199 self-caught off-task reports:

- Mindwandering: On-task=0 (< 3 on the mindwandering scale: 397), Off-task=1 (> 3 on the mindwandering scale: 129);
- Inner speech: Verbal thought=1 (Speech reported: 191, or speech with image: 8, or speech with else: 2), other forms=0;
- Imagery: Imaginal thought=1 (Images reported: 224, or speech with image: 8, image with else: 4), other forms=0;

Note that there were 420 reports of an “Else” form (49.5% of reports).

First of all, proportion of mindwandering in the Articulatory Suppression condition (21.6%) did not significantly differ from either its proportion in Single-task (25.3%, p>.4), nor from its proportion in Foot Tapping (26.9%, p>.3), as statically evidenced by logistic regressions – mindwandering scale=3 and self-caught excluded – with proportion of mindwandering as a dependent variable and condition as predictors (comparing single-task and foot-tapping, separately, to articulatory suppression). The difference between Single-Task and Foot Tapping neither reached significance (p>.8).

Given that no difference in the proportion of mindwandering was found between conditions, we wanted to further assess whether conditions had an effect on the meta-awareness of mindwandering. To this end, we tested whether the number of self-caught reports of mindwandering were significantly decreased in the articulatory suppression condition compared to the two other control condition (single task and foot tapping task). Given that self-caught reports were count data, we ran a Poisson regression on their number,

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² There was a redundancy in the measure of meta-awareness: participants were explicitly supposed to be always unaware when externally probed and at the same time they were asked if they were. This question may have undermined their propensity to self-catch their mindwandering episode, and as a consequence to lie on their meta-awareness scale, saying that they were more unaware (as expected) than they really were. As a consequence, we did not know how to integrate the results from the meta-awareness scale into a global model. We therefore simplified the presentation of the results by adopting Sayette et al. (2009) direct comparison between external thoughts-probes and self-caught reports.
with conditions as predictor. The number of self-caught reports in the articulatory suppression (mean=1.96, SD=2.76) was lower than in both the single task (mean=3.04, SD=3.65; estimate: -0.44, SD=0.18, z= -2.38, p<.05) and the foot tapping condition (mean=3.00, SD=3.32; estimate: -0.42, SD=0.18, z= -2.29, p<.05). The difference between Single-Task and Foot Tapping did not reached significance (p>.9).

We thirdly wanted to assess whether conditions had an effect on the reported form. Logistic regressions – including all thoughts-reports – with inner speech as dependent variable and condition as predictors revealed no main difference between the proportion of inner speech in the Articulatory suppression (21.5%) compared to both Single task (24.2%, p>.4) and Foot Tapping (24.7%, p>.3). The difference between Single-Task and Foot Tapping neither reached significance (p>.9).

Similar logistic regressions with mental imagery as dependent variable revealed that the proportion of mental imagery in the Articulatory suppression (29.6%) tended to be higher than Foot Tapping (24.0%), as statistically evidenced by a marginally effect of Foot tapping compared to Articulatory suppression (estimate: 0.34, SD=0.20, z=1.69, p=0.09). However, the proportion of mental imagery in the single task (29.1%) did not significantly differ from neither articulatory suppression (p>7) nor foot tapping (p>.15).

Following this logic, we finally wanted to assess whether on-task thoughts and off-task thoughts (both classified from external thought-probes) and self-caught reports had different phenomenology. To this end, we conducted logistic regression – across all conditions, mindwandering scale=3 excluded – with inner speech as dependent variable and type of thought as predictor (comparing On-task and Probe-caught Off-task to Self-caught Off-task). It revealed that the proportion of inner speech was significantly higher in the self-caught off task (41.5%) than in both probe-caught off-task (25.4%; estimate: 0.88, SD=0.27, z=3.22, p<.01) and probe-caught on task thoughts (14.2%, estimate: 1.47, SD=0.24, z=6.10, p<.001). The difference between probe-caught off-task and probe-caught on-task did not reach significance (p>.10).

On the reverse, the proportion of mental imagery was lower in the probe-caught on-task (18.5%) than in both probe-caught off task (43.1%; estimate: -1.20, SD=0.25; z= -4.75, p<.001) and self-caught off task thoughts (27.0%; estimate: -0.81, SD=0.24, z= -3.41, p<.001). The proportion of mental imagery was also significantly lower in the self-caught than in the probe-caught off task thoughts (estimate: -0.61, SD=0.25, z= -2.45, p<.05).

**Discussion**

We can summarize the main results of Experiment 1 according to three axes.

First, we can rule out the possibility that articulatory suppression decreased the amount of mindwandering compared to either single task or foot tapping. Not only reported mindwandering (through random thought-probes) did not differ significantly between conditions, but if anything, the indirect measures of mindwandering obtained through the SART show that mindwandering in articulatory suppression, at worse did not differ from foot tapping, and at best was higher than in single task (more state 1 and 2 of disengagement from the task compared to single task).

Second, two lines of evidence suggest that articulatory suppression decreased meta-awareness of mindwandering. The first one comes from the indirect measure of zoning out that arise from the effect of conditions on anticipations. Cheyne et al. (2009) related anticipations to a state 2 of disengagement, explicitly related to zoning out. As a consequence,
the fact that there were more anticipations in the articulatory suppression than in the single task indicates that articulatory suppression increased zoning out. The second line of evidence that suggests that articulatory suppression decreased meta-awareness of mindwandering is that, given a quantity of mindwandering that did not decrease in the articulatory suppression (according to both SART and mindwandering reports), the number of self-caught off-task reports significantly decreased, and this time compared to both single-task (as indicated anticipations) and foot tapping. This selective effect of articulatory suppression therefore undermines the possibility of a mere effect of dual task, and stresses the role of inner speech in meta-awareness. Given that articulatory suppression is a classical means to disrupt inner speech (Baddeley, 1992; Emerson & Miyake, 2003), and given that self-caught off-task reports are reports of meta-aware mindwandering episodes, a significant decrease of self-caught reports due to articulatory suppression gives strong support to the hypothesis that language as a causal role in meta-awareness of mindwandering.

However, a third axis of results tempers this view. On one side, participants did not significantly report having less inner speech (and not even more mental imagery) in the articulatory suppression compared to the control conditions. Therefore, the mediation showing that a first effect of conditions on phenomenology caused a second effect of conditions on meta-awareness was out of reach. On the other side, participant did report that meta-awareness of off-task reported was related to a higher proportion of verbal thoughts (self-caught mindwandering having more inner speech than probe-caught mindwandering). This adds further support to our hypothesis that inner speech plays a role on meta-awareness.

Finally, Smallwood’s suggestion that mindwandering was similar in many aspects to mental imagery received further support: both types of off-task thoughts (meta-aware (self-caught) and less meta-aware (probe-caught)) were reported as being more visual than off-task thoughts – when they could have been more verbal, or more undefined. Our further suggestion that imagery was linked to deeper mindwandering (less meta-aware) was further supported by the finding that probe-caught mindwandering was more visual than self-caught mindwandering. Given that participants could mix forms and that therefore verbal and imaginal variables were independent, this finding provides further support to opposite phenomenologies of tuning out (more verbal and less imaginal) and zoning out (less verbal and more imaginal).

However, this experiment presents three main caveats related to fact that it used a dual task paradigm, self-caught reports and an explicit suppression of inner speech.

Dual task - First, a dual task effect appeared concerning the SART data and may have threatened our conclusions concerning the effect of articulatory suppression. Second, dual tasks are hard to perform due to high demands and this may have biased the data. Even if articulatory suppression and foot tapping are supposed to be matched in difficulties (Emerson & Miyake, 2003), it is possible that the number of self-caught was higher in the foot tapping condition because they simply needed more pauses than in the articulatory suppression and the self-paced interruptions of the dual task that constituted the self-reports may have been very welcomed breaks. The effect would therefore have nothing to do with meta-awareness.

Self-caught reports – First, the meta-awareness scale was redundant with the instruction to self-catch mindwandering and may have therefore placed participants under a double constraint that may have as a consequence undermined the reliability of their reports. Second, one may think that the very act of self-report relies on a spontaneous intention to communicate. As communication heavily relies on language, one may find straightforward that under articulatory suppression, the intention to communicate is impaired with inner
speech, and as a consequence impairs the very act of spontaneous report, without impairing corresponding meta-awareness.

Explicit suppression – First, the manipulation may have been quite explicit to the participant. It is not impossible to realize that articulatory suppression would decrease one’s inner speech, and explicit – or even implicit – association between inner speech and meta-awareness could lead to voluntarily – or not – report less meta-awareness. In other words, a non-naïve participant would be able to bias the data according to the experimenter expectations. Second, given that reported forms did not significantly differed between conditions, mediation was out of reach. This partially undermined the conclusion that inner speech has a causal role on meta-awareness.

Experiment 2 attempted to rule out some of these objections. First, we needed another online manipulation that did not rely on dual task. Second, in order to avoid confusion and to simplify the design, we restricted assessment of meta-awareness to the meta-awareness scale, excluding the possibility for the subject to spontaneously report off-task thought. Finally, to avoid participants to voluntarily bias the data, and given that the mediation was out of reach with a suppression of inner speech, we tried to obtain mediation with implicit induction. We also wanted to include the possibility that more stable personality traits, such as cognitive style, that is to say the preference one may have to think mostly in words or images (Paivio, 1971), could predict meta-awareness of one’s mindwandering.
Experiment 2

Experiment 2 was an online and temporary induction of cognitive style – the preferential processing of information in either a verbal or an imaginal form. In a SART-like task composed of pictures and words instead of numbers, each participant went through three blocks of different picture/words ratio (1/3, 1/2, 2/3) that were not obviously distinguished. Participants were supposed to report more inner speech in the 2/3 of words blocks compared to the 1/2 of words blocks and as a consequence, more meta-awareness (of their mindwandering). Conversely, participants were supposed to report more images in the 2/3 of pictures blocks compared to the 1/2 of pictures blocks and as a consequence, less meta-awareness. Given the little difference between the proportions, and the fact that the order of pictures and words were random, this manipulation was supposed to be implicit.

Methods

Participants: 24 participants from the listing of the Laboratoire de Sciences Cognitives and Psycholinguistique, (referred as LSCP below) volunteered to participate in the study (17 women, 7 men). Their age ranged from 18 to 34 years (M= 23.1, SD= 3.9). All participants of the experiments 2, 3 and 4 had normal or corrected to normal vision and spoke fluent French. Each participant performed in the three different blocks constituting the conditions.

Materials

Pictures – A set of 24 colored pictures of 256x256 pixels were picked from the stimuli base created for the studies of Alvarez, Brady, Konkle and Oliva on massive memory (Brady et al., 2008; Konkle et al. 2010a, 2010b). Two pictures illustrated each one of four animals (dog, cat, bird and butterfly), four objects (key, clock, leaf and mushroom) and four scenes (city, street, mountain and beach). The sixteen animals and objects were on a white background, whereas the eight pictures of scenes fully occupied the 256x256 pixels dimensions.

Go/No-go task – The main task was a SART-like go/no-go task. Instead of numbers, items that were either words or pictures of the corresponding words were sequentially presented at the center of a computer screen (white background, refresh rate of 70Hz). Those items were constructed with a 3 (category: animal / object / scene) x 2 (familiarity: highly / lower familiar to urban life) design in order to ensure their variability and to diminish the importance of the distinction between pictures and words to the participant. Two concepts were attributed to each cell (for example: highly familiar animal were “dog” and “cat”, lower familiar scene were “mountain” and “beach”, see appendix for the table of stimuli). The critical condition was that each concept was represented through two forms: either a picture or a word (Arial, 20). Then, two exemplars of the concept was proposed for each form (e.g.: the concept “dog” was presented with two different pictures of a dog and with two words: low case “dog” or upper case “DOG”). This combination of conditions resulted in a set of 48 items (3 categories x 2 familiarities x 2 different concepts each x 2 forms x 2 exemplars) gathered around 12 different concepts.

For each participant, a concept (e.g. “dog” or “mountain”) was randomly designated as a target for the whole experiment. Participants were asked to press the spacebar as fast and

3 Available (Last updated : 06/03/12) at the web address: http://cvcl.mit.edu/MM/
accurately as possible to the items and to withhold the response when presented with the target concept, regardless of whether it was a picture or a word referring to the target concept. The probability of the target stimulus was 8.3%. The inter-stimulus interval was 1500ms and the duration of each stimulus (target and non-targets) was 2000ms.

Each participant was presented with a unified experiment that was in fact divided in three blocks of equal length. Six repetitions of the two exemplars of each of the twelve concepts composed the 144 trials of each block. As a consequence, these 144 trials included the 12 targets. The trials were in random order so that the positions of the targets were unpredictable.

The three blocks differed by their picture/word ratio, which was 1/3, 1/2 or 2/3, displayed in random order with no pause or clue that would indicate any frontier. These three types of ratios constituted the critical condition of this experiment as they intended to implicitly induce prominently verbal or imaginal thoughts.

The distribution of the form of the target stimuli rigorously represented their type of block. In fact, 4 target trials on 12 were pictures for the block having the 1/3 picture/word ratio, 6 targets trials were pictures in the 1/2 picture/word ratio block, and 8 were pictures in the 2/3 picture/word ratio block.

Thought-reports – Twelve thought-probes randomly interrupted the task in each block. The sole constraint put on their distribution was that half of them had to directly follow pictures-stimuli and the other half of them had to directly follow words-stimuli, regardless of the type of block. This prevented for any trivial effect due to subjects reporting the form of the prior stimulus.

As in experiment 1, participants were first asked the extent to which their last thought was on- or off-task and meta-aware to be so or not on the same 5-points-Likert scales. However, the importance of the meta-awareness scale was more stressed than in experiment 1, given that spontaneous reports of mindwandering were not allowed (not even mentioned).

The question of form of their last thought (third in the order of questions) was however slightly different from experiment 1 and then kept the same for experiment 3 and 4. Deriving from Hurlburt’s (2008) descriptive studies (Hurlburt, 1997; Hurlburt, Koch & Heavey, 2002; Heavey & Hurlburt, 2008), six possible choices were provided regardless of prior answers on the on/off-task and meta-aware scales: (1) Language (Inner Speech) and (2) Images (Inner Seeing in Heavey and Hurlburt’s terminology), identical to experiment 1, (3) Sounds (inspired from Inner Hearing): the participant was having the auditory experience of a mental “image” or memory (e.g. on-task: recalling the instructions via the experimenter voice, e.g. off-task: having a tune in mind). (4) Bodily Sensation (inspired from sensory awareness): the participant was focusing on his/her very body. (5) Emotion (inspired from “feeling”): the participant was focusing on a particular emotion of joy, surprise, sadness, etc. right prior to the probe. (6) Else (inspired from Unsymbolized Thought): the participant was having a thought that was neither in words, images, sounds, or even a sensation or an emotion. This category could also be chosen when the subject could not successfully introspect the form of his/her thought, or had strong doubts.

This question, like the others but in contrast to experiment 1, was a forced choice: participants had to give at least one and only one answer and were told that in front of a multiple form thought, they had to report the most salient and obvious form. This was justified by the fact that in experiment 1, only 14 of the 1010 thought-reports (<1.5%) were mixed forms thought.

Finally, participants were asked about the time orientation of their last thought with the same scale they used in experiment 1.
IDQ-based questionnaire – In order to access participants’ imaginal and verbal thinking habits and skills (aka “cognitive styles”, Paivio, 1971), we edited a French edition (Grebot, 2000) of the Individual Differences Questionnaire (IDQ) (Paivio, 1971, Paivio & Harshmann, 1983). Paivio’s (1971) original IDQ was composed of 86 self-paced statements the subject had to apply to him/herself (“True” button) or not (“False” button). Paivio & Harshmann (1983) proposed a four factor model to fit the questionnaire, which fit in the French edition (Grebot, 2000). The four factors were F1 “verbal habits”, F2 “imaging habits”, F3 “care for verbal correctness” and F4 “daydreaming habits”. As we were exclusively interested in the verbal and imaging habits, we edited a 20 items questionnaire from the 69 items available from Grebot’s (2000) appendix, with 10 items that highly correlated with the “verbal habits” factor (F1) and 10 items that highly correlated with the “imaging habits” factor (F2). An example of the verbal items could be: “I have a rich vocabulary” and one of the imaging items “When I close my eyes, I easily represent to myself a scene I’ve been through”, see appendix for our edited version of the IDQ). The questionnaire was constructed so that six statements positively correlated with the factor and 4 negatively correlated with it. An order based on the original IDQ was set for all participants.

Procedure: After instructions, participants went through a training session of 20 trials (2 targets and 2 thought-probes). As in experiment 1, the experimenter was present to make sure participants had correctly understood the go/no-go task and the thought probes. The experimenter left before the experimental session started.

The experimental session lasted between 30 minutes (at least three 10 minutes blocks with no pause) and 45 minutes, depending on participant’s ability to easily classify their thoughts.

At the end of the experimental session, the subject typed answers to four debriefing questions that ensured implicitness of the manipulation: (1) “According to you, what was the goal of the experiment?”, (2) “Have you noticed anything in particular? If so, what?” (3) “Have you noticed that some proportions of stimuli were changing, and if so, which types of stimuli?” (4) “In fact proportion of pictures and words varied in blocks. According to you, how many blocks were there?”. Once they were told that three blocks existed, one with a majority of pictures, one with a majority of words and one with equal distribution of words and pictures, participants had a forced choice response to give about their order.

Finally, participants completed the IDQ-based questionnaire. The whole experiment lasted between 50 and 60 minutes. At the end of experiment 2 (but also 3 and 4), participants were debriefed, paid 10 Euros and thanked.

Predictions: Given that the task was not a SART anymore; our predictions relied exclusively on the introspective data obtained via external random thought-probes.

Results

Given that according to the debriefing questions, none of the subject identified the manipulation of picture/word ratio, analyses were conducted on all of the 24 participants. As mentioned above, given that the task was not a SART, we had no predictions on RT-CV and anticipations to assess meta-awareness. We simply tested whether the picture/word ratio had any effect on the broad indirect measure of mind-wandering that constitutes errors of commissions (NOGO errors, Mrazek et al., 2011).

To this end, we ran a one-way within participants ANOVA with condition as ordered factor (3 ratios: 1/3, 1/2, 2/3 of pictures/word ratio blocks) on NOGO errors. It revealed no

4 Note that there were only two anticipations (RT<200ms) in the whole experiment.
main effect of condition (p>.149; MoW: 13%; EP: 13%; MoP: 9%). This indicates that the picture/word ratio had no obvious effect on mindwandering.

As in Experiment 1, we then wanted to assess the relations between mindwandering, meta-awareness, phenomenology and the effect conditions had on them. To do so, we computed five binomial variables based on a total of 861 thought-probes:

- Mindwandering: On-task=0 (< 3 on the mindwandering scale: 357), Off-task=1 (> 2 on the mindwandering scale: 389);
- Meta-awareness: Aware=1 (< 3 on the meta-awareness scale: 384), Unaware=0 (> 2 on the meta-awareness scale: 353);
- Inner speech: Verbal thought=1 (Speech reported: 273), other forms=0;
- Visual imagery: Visual thought=1 (Visual Images reported: 218), other forms=0;
- Auditory imagery: Auditory thought=1 (Auditory Images reported: 60), other forms=0;

Note that there were 147 reports of an “Else” form on 861 (20.6% of reports). Given that mindwandering was included as a dependent variable or as a predictor in the following analyses, values that were neither 1 nor 0 (when the mindwandering scale=3) were excluded.

First of all, similarly to the indirect measure of mindwandering obtained through the go/nogo task data, thought-probed reported proportion of mindwandering in the Majority of Words blocks (51.2%) did not significantly differ from neither its proportion in Equal Proportion blocks (52.4%, p>.8), nor from its proportion Majority of Pictures blocks (52.8% p>.6), as statically evidenced by logistic regressions with proportion of mindwandering as a dependent variable and conditions as predictors (comparing MoP and EP to MoW). The difference between EP and MoP neither reached significance (p>.9).

Secondly, we tested whether the Majority of Word had higher meta-awareness of off-task thoughts compared to Equal Proportion and Majority of Pictures blocks. As predicted, introspected proportion of meta-awareness of off-task thoughts in the Majority of Words blocks (43.0%) was significantly higher than its proportion in both Equal Proportion blocks (31.1%; estimate: 1.09, SD=0.40, z=2.76, p<.01), and marginally Majority of Pictures blocks (33.3%; estimate: 0.74, SD=0.38, z=1.93, p<.06) as statically evidenced by a logistic regression restricted to off-task thoughts with proportion of meta-awareness as a dependent variable and conditions as predictors (comparing MoP and EP to MoW) as predictors. The direct comparison between EP and MoP using a logistic regression did not reached significance (p>.3).

Given that we obtained the predicted effect of the Majority of Word blocks on meta-awareness of off-task thoughts, we then wanted to assess whether this effect could be mediated by another effect of the conditions on the reported forms. To this end, we ran a logistic regression restricted to off-task thoughts with verbal thoughts as dependent variable (MoW: 27.1%; EP: 35.2%; MoP: 32.5%) and conditions (comparing EP and MoP to MoW) as predictors. No main effect of condition was found significant (p>.16, p>.48). The logistic regression directly comparing EP and MoP was not found significant either (p>.53).

In summary, we could not show any effect of conditions of the reported phenomenology of participants that could mediate the observed effect on meta-awareness of on-task thoughts.

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5 Due to technical problem, a participant could not finish the task but was done for most of the experiment, which allows for his inclusion in our analyses. However, this participant did not complete the IDQ-based questionnaire and could therefore not be included in analyses involving cognitive style.
Given this failure to mediate the effect of conditions on meta-awareness by the reported phenomenology, we tested whether we could replicate the relation found in the Experiment 1 between verbal thoughts and meta-awareness of mindwandering. Going one step further in the reasoning, we were not anymore interested about differences in the phenomenology between tuning out (more verbal) and zoning (out more visual), but we then wanted to test whether the very phenomenology was predicting meta-awareness of off-task thoughts, or, in other words, whether the fact that an off-task thought was verbal (instead of visual for example) would increase its probability to be meta-aware.

To test this hypothesis, we first ran a logistic regression restricted to off-task thoughts with meta-awareness as dependent variable and verbal thoughts proportion as predictor. The proportion of meta-awareness in verbal thoughts did not significantly differ from the proportion of meta-awareness in non-verbal thoughts.

However, a similar regression, but with auditory thoughts as predictor revealed that auditory thoughts were significantly more meta-aware when off-task than non-auditory thoughts. This slightly deviant confirmation of our expectations suggests that the distinction between verbal and auditory thoughts might have been not clear enough in experiment 2, or that the relation obtained in experiment 1 might have been due to the auditory component of the “inner speech” reported.

Finally we assessed whether cognitive style factors could predict the proportion of meta-awareness of on- and off-task conscious experiences. A logistic regression with meta-awareness as dependent variable and scores of “Verbal habits” and “Imaging habits”, both in interaction with mindwandering, as predictors did reveal no main effect of verbal habits (p>.6) or imaging habits (p>.3) or mindwandering (p>.1) but a significant interaction between imaging habits and mindwandering (p<.05) indicating that imaging habits specifically (though marginally) negatively predicted meta-awareness of mindwandering (estimate: -0.66, SD=0.40, z= -1.66, p>.10) but not meta-awareness of on-task thoughts (p>.3). The interaction between verbal habits and mindwandering did not reach significance (p>.3).

**Discussion**

Experiment 2 successfully induced meta-awareness of off-task thoughts via a manipulation that intended to implicitly induce inner speech. This effect was obtained without any concurrent effect on the propensity to mindwandering (as indicated by no-go errors and introspective reports). This stresses a very effect of the conditions (picture/word ratio) on meta-awareness of off-task thoughts: in other words, off-task thoughts were more aware, and it was not due to a particular increase in any of the number of “tuning out” or “zoning out” from a mindwandering baseline, as it tended to be the case in experiment 1.

In summary, experiment 2 constitutes a fair replication of experiment 1 and therefore rules out most of the possible biases we highlighted in the experiment 1 discussion – particularly due to the use of dual task and self-caught mindwandering reports, and to the explicitness of the manipulation. However experiment 2 had its own drawbacks, mainly that given the absence of reported changes in phenomenology due to conditions that in addition have not been supported by the literature yet, one may suspect that the effect we obtained on meta-awareness was due to a very induction of inner speech. The induction of inner speech in Experiment 3 therefore heavily relied on a well-established literature of an increase of verbal

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6 N=23 because of a participant that did not complete the IDQ due to technical problems.
ruminations under stereotype threat. Experiment 3 was also designed to stand back from the very form of stimuli and hence avoid any zombie-like phenomenological report.

Now that the possibility of a bias coming from the use of self-caught reports had been ruled out, Experiment 3 also further explored the very differences between the external thought probes method and the spontaneous off-task method. Experiment 3 was finally designed to further disentangle caveats concerning the difference between auditory and verbal thought reports and the IDQ ability to predict meta-awareness of off-task thoughts.
Experiment 3 - Methods

As we needed an induction of inner speech that was strongly supported by the literature, Experiment 3 was based on both stereotype threat (Steele, Spencer & Aronson, 2002; Schmader, 2010; Schmader et al., 2008, 2009) and public speaking threat effects (Davidson, Marshall, Tomarken & Henriques, 2000). More precisely, it was designed to induce respectively verbal and imaginal mindwandering episodes.

Following a first line of research, stereotype threat relates to the finding in social psychology that when placed in front of a test that may reveal a stereotype concerning the participant, and when the stereotype is also stressed (for example a female participant is remembered of the stereotype that females have lower skills in mathematics than males just prior to perform on a arithmetic task), the participant will tend to act accordingly to the stereotype more than another participant to whom the stereotype is not stressed (Spencer, Steele & Quinn, 1998). To account for this effect, stereotype threat has been explicitly related to verbal ruminations. In fact, on one hand participants introspectively report these ruminations. On the other hand, stereotype threat specifically impairs verbal working memory, suggesting that the phonological loop may indeed be already busy with spontaneous verbal thoughts (Beilock et al., 2007; Schmader & Johns, 2003). Moreover, it is to note that stereotype threat has recently been shown to increase mindwandering (Mrazek et al., 2011). Given that we wanted to use the SART because it allows indirect measures of “tuning out” and “zoning out”, we used the stereotype that, nowadays, young adults had a worse ability to sustain attention and stay focused during a long time than the previous generation (“partially due to a greater use of new technologies”). To ensure both the stereotype threat effect and the possibility to compare it to control participants, all were under 25 years old.

Building on another line of research, mere anxiety of coming events has been shown to selectively impair visual memory (Shackman, Sarinopoulos, Maxwell, Pizzagalli, Lavric, & Davidson, 2006). Public speaking anxiety, that is the anxiety to talk in front of many persons, coupled with cognitive evaluation, has moreover been identified as the most anxiety-triggering events (Dickerson & Kemeny, 2004). We reasoned that even if anxiety-driven impairment of visual working memory came from neurological evidence (Davidson, et al., 2000, Shackman et al., 2006), it could be consistent with the data, and introspectively plausible that this impairment partly came from imaginal mindwandering episodes that would siphon off working memory resources, in the same fashion that verbal ruminations do under stereotype threat. Given that we had no interest into the very act of speaking in public, we restrained the manipulation to a public speaking threat, which is to say to the anxiety triggered by the anticipation of the public speech, and none of the participants actually had to talk in public.

In contrast to experiments 1, 2 and 4, experiment 3 was conducted on a three independent groups design, such that the experimental manipulations could be effective. The stereotype threat group was supposed to report more inner speech compared to the control group, and therefore, more meta-awareness (of their mindwandering). Conversely, the public speaking threat group was supposed to report more images compared to the control group, and therefore, less meta-awareness (of their mindwandering).

We also tested for differences between spontaneous and external thought-reports, differences that had never been explicitly highlighted or ruled out in the context of mindwandering, at least to our knowledge. Each participant was therefore tested using both methods separately (respectively a method where spontaneous reports were required (“S-method”) and a method that they did not exist (“P-method”)). The method order was counterbalanced across participants.
Methods

Participants: 47 participants from the listing of the LSCP volunteered to participate in the study (37 women, 10 men). Their age ranged from 18 to 25 years (M=21.3, SD=2.0). All participants had normal or corrected to normal vision.

They were randomly assigned to one of six (3 conditions x 2 orders of methods) independent groups: Control Group (CG) with Probecaught-Selfcaught (P-S) order (N=8, Mean Age=21.4, SD=2.1), CG with Selfcaught-Probecaught (S-P) order (N=9, M=21.2, SD=2.1), Stereotype Threat Group (STG) with P-S order (N=7, M=20.6, SD=2.3), STG with S-P order (N=8, M=21.0, SD=1.9), Public Speaking Threat Group (PSTG) with P-S order (N=8, M=21.4, SD=1.9), PSTG with S-P order (N=7, M=22.1, SD=2.0).

A 3 (Conditions) x 2 (Orders) ANOVA did not reveal any significant difference on age between groups (all p>.45), which makes them comparable when studying the age-related stereotype threat.

Materials

Instructions – The three experimental conditions relied essentially on the instructions given to the participant (see appendix for the exact instructions). The control group was told that their performance would be compared to other students (or young adults if the participant was not student anymore). In contrast, the stereotype group was told that their performance on a sustained attention task would be compared to the performance of older participants (30-45 years old), in order to assess whether this task would also indicate the “widely scientifically observed decrease in young adults’ focus capacities”7. As for the public speaking threat group, they were told that their performance would be compared to a later performance of public speech that would occur in the last third of the experiment, where they would have to quickly prepare a talk (the topic would be given then) and to then execute it in front of two professors that would take notes about their personality and performance (public speech + cognitive evaluation). The fact that the vigilance performance was either compared to other young adults’ performance or to the subject’s own performance was supposed to control for the very effect of stereotype threat (as the performance would be evaluated anyway). To control for the very effect of public speaking threat, we also told participants in the control and stereotype threat conditions that they would have to complete a personality test in the last third of the experiment. This excluded any mere effect of anticipation of the future events and or any mere effect due to the fear of having one’s personality measured.

SART – The SART was identical to Experiment 1, except that the probability of the target stimulus was now 8.7%. As we used two probing methods, the underlying SARTs were still slightly different. Inspiring us from Stawarczyk et al. (2011), the SART underlying the “P-method” was composed of eighteen blocks of six different sizes (three blocks of each length): 16 (1 target), 20 (2 targets), 23 (2 targets), 26 (2 targets), 30 (3 targets) or 33 (3 targets) trials. On the contrary, the SART underlying the “S-method” was composed of six blocks ranging from 66 to 82 trials (6 to 7 targets). This way the two SARTs had a comparable number of trials (P = 444, S = 443) and targets (P = 39, S = 38). The place of each target was pre-randomized such that none of them was less than 3 non-targets to the next target, nor to the end of the block.

7 Participants were all debriefed at the end of the experiment in order to cancel this information.
Thought-reports – Two thought-report methods were separately used in the two parts of the experiment: the S-method (S for Spontaneous) and the P-method (P for Probed). The main difference relied on the fact spontaneous reports of mindwandering were crucially required in the S-method (their importance was stressed to the participant) whereas they were not available in the P-method. Given that each part was composed of blocks of different length, and given that each block was immediately followed by an external thought-probe which interrupted the task, external probes existed in both S-method and P-method. They were just the only way to report mindwandering in the P-method.

As in experiment 1 and 2, thought-probes first asked to what extent their last thought was on-task or not, and whether it was meta-aware or not. However, we slightly changed these two questions, keeping the form and time orientation questions identical to experiment 2. Using Stawarczyk et al.’s (2011) classification, four possible choices were provided to answer the first question: (1) “Task and Stimulus” (“On-task reports” according to Stawarczyk’s terminology): on-task and focused on the very numbers being displayed or monitoring performance on the task; (2) “Task-related” (“Task-Related and stimulus Independent (TRI) reports”): thoughts about the task with no focus on the numbers anymore (e.g. thinking about a past mistake or wondering how the numbers were organized). (3) “Immediate Environment” (Environment Dependent (ED) reports): focus on task-unrelated immediate environment (e.g. thinking about luminance, temperature, noises, or even interoceptive sensations such as thirst, hunger or fatigue). This category was also described as mere distraction from the task. (4) “Elsewhere” (mindwandering reports): the participant’s attention was not focused on the task or on directly available stimuli anymore.

In the “P-method” part only, participants were secondly asked about their meta-awareness of the ongoing conscious experience they had just prior to the probe. Two possible choices were always provided. They could either (1) say that they knew what their conscious experience was prior to the probe, that is to say that they were meta-aware of it; or (2) that the probe made them notice or realize what they were thinking about, that is to say that they were not yet meta-aware of it prior to the probe.

In both parts, participants were then asked about the form and time orientation of their last thought. These alternatives were identical to that of experiment 2.

Note that when in the “S-method” part, participants had to spontaneously report their mindwandering through “self-caught mindwandering reports”, hence behaviorally testifying that they were indeed meta-aware of their mindwandering. As a consequence, these self-caught reports only questioned the form and time orientation of the (by definition) meta-aware mindwandering episode. As another consequence and to increase the motivation of the participant to report off-task thoughts he would be meta-aware of, thought-probes in the “S-method” resulting in a report of mindwandering were automatically categorized as “unaware episodes”. In fact, if the subject had been aware of it, he/she should have reported it.

Mood Questionnaire – Inspired from Schmader & Johns (2003), we used a seven items questionnaire accessing on seven-point Likert-scales (ranging from “Not-at-all” to “Totally”) the extent to which participants were currently feeling anxious, comfortable, annoyed, at ease, nervous, relaxed and calm. The order was kept constant. The anxious, annoyed, and nervous items were conversely scored to obtain a consistent score of mood.

Individual Difference Questionnaire – As in experiment 2, we wanted to assess participants’ cognitive styles. However, given the partially unsatisfactory results of our 20-items edition of the IDQ, experiment 3 and 4 both used each of the 69 items available from the French edition of the IDQ (Grebot, 2000). The “Verbal habits” (F1) and the “Imaging
habits” factors (F2) were still of particular interest as they precisely assessed participants’ cognitive style. Yet, the “Care for verbal correctness” (F3) and the “Daydreaming habits” factor (F4) were also computed (Paivio & Harshmann, 1983).

Procedure: Participants first completed the mood questionnaire. They were then administered the critical instructions as described in the Materials subsection, plus instructions about the SART and the P- or S-methods. After instructions, they received a reminder related to their condition (encouragements for the Stereotype group and the experiment plan mentioning professors for the Public Speaking group). After watching a “Part 1/3” indication, they perform the training session (20 trials, 2 targets and 2 thought-probes) corresponding to the S- or P-method that would directly follow as experimental session.

The experimenter left the room right before the first experimental session started.

Once done with the first part, participants completed a second mood questionnaire. They were then instructed of the changing of thought-report method and the corresponding ways of reporting their awareness of their mindwandering. After being presented with a “Part 2/3” indication, they had another training session and then completed the second experimental session (Part 2). When the second part was done, participants completed a third mood scale.

They were then asked two manipulation checking questions: “Judge these statements as true or false”: (1) “You are now going to talk to two professors” (2) “Sustained attention of young people is worse than sustained attention of the previous generation”. In fact, question 1 provided a rough estimate of how effective had been the public speaking threat (only group supposed to answer “true”) and question 2 provided on one side an estimate of how effective the stereotype threat message had been on the stereotype threat, and also a possible check of the very existence of this stereotype among the control and public speaking groups that were not told anything about age differences in sustained attention.

The participants were then required to type the answer to a first debriefing question: (1) “According to you, what was the goal of the experiment?”. Right after, the public speaking threat group was told that they would not have to speak in front of professors, but were instead proposed to complete a questionnaire of personality (the IDQ). However, they were first required to type answers to three other debriefing questions: (2) “Do you have any particular remark?” (3) “Have you felt any difference in your thought between the two parts? (4) “What do prefer between the spontaneous report method and the purely automatic report method?”

Finally, participants completed the 69 items available from the French edition of the IDQ (Grebot, 2000). The whole experiment lasted between 50 and 60 minutes.

Predictions: As in experiment 1, increases in meta-awareness for the stereotype threat condition could be expressed in two ways.

Introspectively, they correspond to an increase in the proportion of meta-aware (S-method: self-caught off-task thoughts or P-method: “known” mindwandering) compared to not-meta-aware mindwandering (S-method: probe-caught off-task thoughts or P-method: “unnoticed” mindwandering).

Psychophysically, and identically to experiment 1, it corresponds to increase in RT CV and anticipations.

Results

Given that according to the debriefing questions, none of the subject correctly identified the goal of the experiment (induction of inner speech and/or of meta-awareness), analyses were conducted on all of the 47 participants.
SART and indirect measures of mindwandering

As in Experiment 1, we first examined the effect of conditions, but also of thought-report method, on RT CV and anticipations of the SART-data.

To this end, we first ran a 3 conditions (between participants) x 2 thought-report method (within participants) ANOVA on RT CV. None of the main effect of condition (control: 0.24, stereotype threat: 0.22, public speaking threat: 0.23) or method (S-method: 0.23, P-method: 0.23) reached significance (respectively p>.2 p>.3). Neither did their interaction (p>.6).

A similar 3x2 ANOVA on anticipations did not revealed main effect of condition (control: 4.1, stereotype threat: 3.4, public speaking threat: 2.8; p>.7) or method either (S-method: 4.0 P-method: 3.0; p>.2). The interaction was again non-significant (p>.2).

Thought-reports

In a second move, we examined the effects of conditions and thought-report method on the reported mindwandering, phenomenology and meta-awareness.

To this end, and similarly to experiment 2, five binomial variables were computed among the total of the 1240 thought-probes (297 Task Related but stimuli Independent reports were discarded, because of their proximity in the experiment to both on-task and off-task reports):
- Mindwandering: On-task=0 (413), Off-task=1 (827: S-Off-task: 364 + P-Off-task: 463 )8;
- Meta-awareness: Aware=1 (P-Aware: 436, S-Aware: 364), Unaware=0 (P-Unaware: 195, S-Unaware: 245);
- Inner speech: Verbal thought=1 (Speech reported: 273), other forms=0;
- Visual imagery: Visual thought=1 (Visual Images reported: 218), other forms=0;
- Auditory imagery: Auditory thought=1 (Auditory Images reported: 60), other forms=0;

Note that there were 143 reports of an “Else” form on 1240 (11.53% of reports, when TRI excluded). As mentioned above, only 297 TRI were excluded from analyses.

First of all, in order to assess effects of conditions and of thought-report methods in the proportion of mindwandering we ran a logistic regression with mindwandering (Off-task = 1, On-task=0) as dependent variable and both condition (that compared both stereotype and public speaking threat to the control condition) and thought-report method (S-method vs P-method) as predictors.

It revealed that proportion of mindwandering in the control condition (71.1%) tended to be higher than in the Stereotype threat condition (59.7%; estimate: -0.78, SD=0.43, z= -1.83, p<.07), but did not differ from its proportion in the Public Speaking threat condition (69.3%, p>.6). This regression also revealed that the proportion of mindwandering reports was significantly higher in the S-method (82.6%) than in the P-method (51.3%; estimate: 1.60, SD=0.25, z=6.50, p<.001). None of the interactions between thought-report method and public speaking threat (p>.8) or the effect of stereotype threat reached significance (p>.5). A similar logistic regression directly comparing stereotype threat to public speaking threat condition only confirmed the main effect of thought-report method on mindwandering.

8 Given that no obvious behavioral difference has been given between Environment-Dependent thoughts and Stimulus-Independent and Task-Unrelated Thoughts (Stawarczyk et al., 2011), we broadly classified as “Off-task” thoughts both of them.
proportion (estimate: 1.68, SD=0.30, z=5.61, p<0.001) but did not revealed any main effect of condition (p>0.2) or any interaction with thought-report method (p>0.6).

Secondly, we wanted to assess whether conditions and of thought-report method had an effect on the meta-awareness of mindwandering. We ran a logistic regression with meta-awareness as dependent variable and condition (comparing both stereotype and public speaking threat to control condition) thought-report method and mindwandering as predictors. It revealed that control condition (59.3%) had significantly lower meta-awareness than both stereotype threat (69.9%; estimate: -1.28, SD=0.43, z=3.00, p<0.01) and public speaking threat (64.7%; estimate: 1.42, SD=0.47, z=3.00, p<0.01). It revealed no main effect of thought-report method (S-method: 60%, P-method: 69%, p>0.9) and no main effect of mindwandering (on-task: 60.3%, off-task: 66.6%, p>0.1). Of particular interest, the increase of meta-awareness obtained in the public speaking threat condition was specific to on-task thoughts (estimate: 0.84, SD=0.41, z=2.04, p<0.05) and on the contrary non-significant among off-task thoughts (p>0.8) as statistically evidenced from the significant interaction between public speaking threat and mindwandering (p<0.05). In contrast, the similar interaction with stereotype threat did not reach significance (p>0.3) indicating that stereotype threat increased meta-awareness of both on- and – crucially – off-task thoughts. Other interactions including thought-probe method did not reach significance (all p>0.9). A similar logistic regression directly comparing stereotype threat to public speaking threat condition revealed that meta-awareness in these conditions did not differ significantly (p>0.8).

Given that we obtained the predicted effect of stereotype threat on meta-awareness, we thirdly wanted to assess whether this effect could be mediated by another effect of the conditions on the reported forms. To this end, we ran a logistic regression with verbal thoughts as dependent variable and conditions (comparing both stereotype and public speaking threat to control condition) as predictors. The main effects of conditions (Control: 30.4%; Stereotype Threat: 36.3%; Public Speaking Threat: 34.0%) were not found significant (control vs. stereotype: p>0.8, control vs. public speaking: p>0.2), nor was the effect of thought-report method (S-method: 32.5%, P-method: 34.4%, p>0.3). However, on-task thoughts (52.1%) were found to be significantly more verbal than off-task thoughts (24.2%; estimate: -2.14, SD=0.35, SD= -6.03, p<0.001). None of the interaction between predictors was found significant (all p>0.2).

A similar logistic regression with visual thought as dependent variable led to similar results (no main effect of condition – both comparisons to control condition: p>0.3 – or of the thought-report method – p>0.4 – and no interactions – all p>0.5). The proportion of visual thoughts was however significantly higher in off-task (32.0%) than in on-task thoughts (13.3%; estimate: 1.44, SD=0.39, z=3.69, p<0.001).

Finally, another similar logistic regression with visual thought as dependent variable led to quite similar results: no main effect of thought report method (p>0.9), but a non-significant effect of mindwandering (off-task thoughts 9.9% were not significantly more auditory than on-task thoughts 4.4%. p>0.1), and two marginally significant tendencies that the control condition would have less auditory thoughts (6.0%) than both stereotype threat (8.5%; estimate: 2.21, SD=1.14, z=1.94, p>0.06) and public speaking threat condition (10.1, estimate: 1.98, SD=1.17, z=1.69, p<0.10). However, given that these two last effects did not hold anymore in similar logistic regressions but restricted to off-task thoughts (both p>0.1), we did not conclude to a successful induction of auditory thoughts that would allow for mediation with the effect of conditions on meta-awareness.
Given the absence once again of a potential mediation of the effect of conditions on meta-awareness via an effect of conditions on the reported phenomenology, we still aimed at replicating the relations between verbal thoughts (Experiment 1) or auditory thoughts (Experiment 2) with meta-awareness of off-task thoughts.

To test these hypotheses, we first ran a logistic regression restricted to off-task thoughts with meta-awareness as dependent variable and verbal thoughts proportion as predictor. The proportion of meta-awareness in off-task verbal thoughts (77.0%) significantly differed from the proportion of meta-awareness in off-task non-verbal thoughts (63.3%, estimate: 0.62, SD=0.2032, z=3.04, p<.01).

On the contrary, a similar regression, but with auditory thoughts proportion as predictor, did not revealed a significant prediction (p>.3), neither did the visual thoughts predictor (p>.7).

Finally we assessed whether cognitive style factors could predict the proportion of meta-awareness of mindwandering. A logistic regression restricted to off-task thoughts, with meta-awareness as dependent variable and scores of “Verbal habits”, “Imaging habits” as predictors revealed that imaging habits could marginally negatively predicted meta-awareness of off-task thoughts (estimate: -0.08, SD=0.05, z= -1.84, p<.07). However, “verbal habits” was not a significant predictor of meta-awareness of mindwandering (p>.2).

This pattern of results replicates the findings that meta-awareness of mindwandering is positively predicted by the proportion of verbal thoughts (Experiment 1) and negatively predicted by imaging habits of daily life (Experiment 2).

**Discussion**

As experiment 2, experiment 3 successfully increased meta-awareness of mindwandering with a manipulation aiming at increasing verbal thoughts. The results were even more convincing given that, compared to experiment 2 where lack of support from the literature could undermine the very results, mechanisms of stereotype threat have now been extensively discussed and explicitly related to an increase in verbal rumination.

Moreover, an interesting result arises from experiment 3 concerning the increase of awareness in the public speaking group. This supports our conclusions given that compared to the stereotype-related increase in awareness; the public-speaking related increase of awareness was exclusively present in on-task thoughts, and not in off-task thoughts. Beyond the discussion of this very result that could suggest that public speaking threat prevented participants to enter in a deep state of focusing, it also suggests that only the stereotype manipulation was successful in increasing participants’ awareness of their global stream of thought, including their off-task thoughts.

Also, the very prediction of verbal thoughts and imaging habits on meta-awareness were replicated, indicating that both proximal and distal phenomenological characteristic could be related to meta-awareness of mindwandering.

A second interesting result comes from the observation that no obvious difference arose from the spontaneous and external thought reports. In fact, indirect measures of mindwandering did not seem affected, nor reported meta-awareness. The sole difference relied on a naturally higher proportion of mindwandering reports among spontaneous reports, probably due to the double action of, on one side, few external probes (and hence few occasions to be caught zoning out) and of, on the other side, unlimited spontaneous reports. This is actually what participants reported when asked about their preferences: they preferred the spontaneous report because it was “closer” to their experience of mindwandering, and they could feel more involved into their very introspection.
However, experiment 3 still displayed non negligible drawbacks. The very fact that the mediation via the reported phenomenology was out of reach may not be of primary importance given the well-established relation between stereotype threat and verbal rumination. Nevertheless, this very relation may itself raise critics. Given that mindwandering has been shown to increase under stereotype threat, one may argue that our effect was only due to an addition of very salient thoughts, which were coincidently verbal – because they analyzed the very words of the instructions for example. This in itself does not constitute a change in the processing of mindwandering leading to greater use of inner speech that would lead to greater meta-awareness. This critique is however undermined by the fact that participants reported having less mindwandering in the stereotype threat condition than in the control condition. Hence, any increase in the proportion of awareness cannot only arise from simply adding task unrelated thoughts that are both salient and verbal to a mindwandering baseline.

This point still underlines something, we are not sure that a very change in the processing of information has changed under stereotype threat. Experiment 4 aimed to provoke changes in this very processing. As experiment 1, it should be a suppression manipulation, but without the drawbacks experiment 1 displayed (dual task, self-caught mindwandering reports). Unlike experiment 3, it had to be an online manipulation. Finally, given that reasonable evidence had been given of a role of inner speech on meta-awareness through experiments 1 to 3, we aimed at replicating this very effect with a last experiment, but also to further explore the relation between mental imagery and meta-awareness. What would happen if mental imagery was manipulated by a more rigorous condition that foot tapping, a high picture/word ratio or a public speaking threat?
Experiment 4

As we aimed at further explore the very causal role of both inner speech and mental imagery, Experiment 4 was based on the noise literature (Poulton, 1977) that has the advantage to offer symmetric disruption of either the phonological loop or the visuospatial sketchpad in working memory (WM).

In fact, the Irrelevant Sound Effect (ISE) has shown that irrelevant a-periodical sounds (including speech) interfere with verbal WM (Salamé & Baddeley, 1982; Hughes & Jones, 2001). Conversely, visual noise has been shown to interfere with voluntary mental imagery (Quinn & McConnell, 1996), and hence with visual WM.

Using two types of SART, the classical “visual” one displayed on a computer screen, and an original, auditory one, displayed through earphones, we placed each participant in front of four conditions. They were a virtual crossing of the 2 SART modalities (visual and auditory) with two levels of complementary noise (low and high noise). In the visual SART, high auditory noise (reversed speech) was supposed to disrupt verbal working memory more than low auditory noise (white noise). Conversely, in the auditory SART, high visual noise (dots moving randomly) was supposed to disrupt visual working memory more than low visual noise (static dots). As a consequence, high level of auditory noise was predicted to decrease meta-awareness of mindwandering compared to low level of noise. Moreover such a design allowed to the very test of the effect of disruption of mental imagery on meta-awareness of mindwandering.

Methods

Participants: 34 participants from the listing of the LSCP volunteered to participate in the study (21 women, 13 men). Their age ranged from 19 to 30 years, with a mean age of 23.73529 years (SD= 3.527458). All participants had normal or corrected to normal vision and audition and speak French fluently. Each subject performed in the 2 (modality of the SART: visual / auditory) x 2 (noise: silent / noisy) different blocks constituting the conditions.

Materials

Visual Noises – 450 white dots (radius = 2pixels) were displayed at random positions on a black screen each time the screen refreshed to create a high level of visual noise. The low level of visual noise was obtained with continuous displaying of one random distribution of dots.

Auditory Noise – Audacity software helped creating both low (White noise, 44100 Hz) and high levels of auditory noise (reversed speech). Reversed speech was edited from Ludovic Coudert’s reading of the chapter 1 of La pensée et le mouvant of Henri Bergson. Silences above 1 second were truncated to ensure a quite continuous stream of voice.

SART – The visual SART displayed stimuli on a white font on a black screen whereas the auditory SART displayed stimuli through earphones. This difference set apart, the structure of the two types of SART was identical to SART of the P-method part in Experiment 3, except that they were composed of ten blocks of five different sizes (two blocks of each length): 16

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9 Available (Last updated : 06/04/12) at the web address : [http://www.litteratureaudio.com](http://www.litteratureaudio.com)
(1 target), 20 (2 targets), 23 (2 targets), 26 (2 targets), 30 (3 targets) trials for a total number of 230 trials and 20 targets (target probability 8.7%).

Stimuli presentation in the visual SART was also identical to experiment 1 and 3 (displayed 500ms, interstimulus interval 1500ms). However, in the auditory SART, vocal onsets of numbers were around 100ms, and depending on the number, the full pronunciation could last from 200ms (“1”) to 500ms (“5”) (mean=370ms, SD=91). Note that the full pronunciation of the target “3” (300ms) was within one standard deviation to the mean and then did not particularly differ in length from the other numbers. As in the visual SART, the onsets of two stimuli were separated with 2000ms.

**Thought-probe** – As in experiment 3, each block was immediately followed by a thought-probe which interrupted the task. The question about mindwandering was however simplified. The “Environment-Dependent thought” (mere distraction) was dropped, leaving three possibilities: (1) “On-task reports”, (2) “Task-related concerns” and (3) “Task-unrelated concerns” (i.e. “mindwandering”).

Question about awareness and form were identical to Experiment 3.

However, order of the form possibilities and order of mindwandering, awareness and form questions were randomized for each thought-probe to ensure that there was no position effect responsible of the correlation between “aware” and “language” reports found in the previous experiments. Question about time orientation was dropped too as for the possibility to spontaneously report mindwandering.

**IDQ** – The version of the IDQ was identical to experiment 3.

**Procedure:** Two training sessions of 24 trials each (2 targets and 2 thought-probes) were proposed, one with the visual SART and the other with the auditory SART (both without night). Participants were then told about the existence of noise that would be displayed in the modality not occupied by the SART. Nothing was told about the differences between “noises” in the same modality, but the subject knew that there would be four blocks of approximately 10 minutes each. The experimenter left right before the experimental session started.

At the end of the experimental session, the subject typed answers to six debriefing questions: (1) “Do you have any particular remark?” (2) “According to you, what was the goal of the experiment?”, (3) “Have you felt differences in your thoughts... between the auditory and visual task? (4) “...between the two auditory tasks?” (5) “...between the two visual tasks?” (6) “Do you have any other remark?”

Finally, participants completed the IDQ. The whole experiment lasted between 55 and 65 minutes.

**Results**

Given that according to the debriefing questions, none of the subject correctly identified the goal of the experiment (suppression of inner speech and/or of meta-awareness), analyses were conducted on all of the 34 participants.

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**SART and indirect measures of mindwandering**

As in Experiment 1 and 3, we first examined the effect of modality and levels of noise on RT CV and anticipations of the SART-data.
To this end, we first ran a 2 modality (visual vs. auditory SART) x 2 levels of noise (high vs. low) within participants ANOVA on RT CV. It revealed a main effect of modality ($F(1,33)=71.5$, $\eta^2=0.684$, $p<.001$) indicating that the visual SART had higher RT CV (0.29) than the auditory SART (0.17). The main effect of noise and the interaction were not significant (both $p>.3$).

A similar 2x2 within ANOVA on anticipations revealed a marginal main effect of noise ($F(1,33)=3.8$, $\eta^2=0.102$, $p<.07$) indicating that high levels of noise tended to increase the number of anticipation (1.24) compared to low levels of noise (0.59). Of particular interest, the interaction was also marginally significant ($p<.08$), indicating that the effect of noise was mostly significant for the visual SART (and hence the auditory noise, $F(1,33)=3.8$, $\eta^2=0.104$, $p<.06$), but did not apply to the auditory SART and its visual noise ($p>.3$).

This pattern of result indicates that visual SART had more state 1 (tuning) than auditory SART, when noise increase state 2 (zoning out). Crucially, the marginally interaction suggests that the increase of state 2 due to noise is specific to high levels of auditory noise and may not apply to visual noise. This pattern of results roughly corresponds to our predictions.

### Thought-reports

In a second move, we examined the effects of conditions and thought-report method on the reported mindwandering, phenomenology and meta-awareness.

To this end, and similarly to experiment 2 and 3, five binomial variables were computed on a total of the 1360 thought-probes:
- Mindwandering: Focused=0 (On-task: 488), Unfocused=1 (450 Off-task + 422 Task related thought);
- Meta-awareness: Aware=1 (762), Unaware=0 (598);
- Verbal thought=1 (Speech reported: 400), other forms=0;
- Visual thought =1 (Visual Images reported: 245), other forms=0;
- Auditory thought =1 (Auditory Images reported: 154), other forms=0;
Note that there were 324 reports of an “Else” form on 1360 (23.823% of reports).

First of all, in order to assess effects of modality and noise level in the proportion of mindwandering we ran a logistic regression with mindwandering (Unfocused = 1, Focused=0) as dependent variable and modality and noise levels as predictors. It revealed that proportion of mindwandering in the high noise level (69.1%) was higher than in the low noise level (60.1%; estimate: 0.39, SD=0.17, $z=-2.27$, $p>.05$). The main effect of modality was however not significant ($p>.7$). Neither was the interaction between modality and noise ($p>.8$), indicating that both auditory and visual noise increased mindwandering.

Second, and crucially to our predictions, we wanted to assess whether noise level in the visual SART would impact on meta-awareness of off-task thoughts. We ran a logistic regression restricted to off-task thoughts in the visual SART, with meta-awareness as a dependent variable and level of auditory noise as predictor. It revealed that meta-awareness was however not significant ($p>.7$). Neither was the interaction between modality and noise ($p>.8$), indicating that both auditory and visual noise increased mindwandering.

Given that the predicted effect on mindwandering meta-awareness was obtained, we thirdly wanted to assess whether noise level in the visual SART also impacted the reported phenomenology. To this end, we ran a logistic regression restricted to off-task thoughts in the
visual SART, with verbal form proportion as a dependent variable and level of auditory noise as predictor. It revealed the result that proportion of verbal thoughts tended to be higher under high auditory noise compared to low auditory noise (estimate: -0.41, SD=0.23, z=-1.82, p>.07). This very surprising result – as we were expecting the exact contrary – raised doubts concerning the validity of participants’ phenomenological reports in this experiment (see Discussion). They were therefore not further explored.

Fourthly, we wanted to access whether visual noise level in the auditory SART had any effect on meta-awareness of off-task thoughts. We ran a logistic regression restricted to off-task thoughts in the visual SART, with meta-awareness as a dependent variable and level of auditory noise as predictor. It revealed no main effect of visual noise level (p>.2).

We finally assessed whether cognitive style factors could predict the proportion of meta-aware conscious experiences. Two subjects that responded faster than 1000ms for more than 5 items of the IDQ were excluded from analyses (N=32).

The logistic regression restricted to off-task thoughts, with meta-awareness as a dependent variable and the “Verbal habits” and “Imaging habits” factors as predictors did not revealed that any of the two factors could significantly predict awareness (both p>.3).

Discussion

On one hand, Experiment 4 was successful into replicating with another methodology the fact that one could manipulate meta-awareness of mindwandering with manipulations of inner speech. This replication held for both indirect measures of mindwandering based on SART-data and for reported mindwandering and meta-awareness. Together they revealed that the very number of zoning out increased under high levels of auditory noise (from 92 reports to 123 reports (+33%), but also given the increase in anticipations) when conversely tuning out did not decreased as fast (from 100 to 92 (-8%), with no change in RTCV). This observation adds further evidence for a crucial role for inner speech: it would help diminishing the number of zoning out and hence overall mindwandering.

On the other hand, Experiment 4 was somehow useful unsuccessful. In fact, mediation was again out of reach. However it was for a different reason: participants may have adopted a “zombie-like” introspection of their phenomenology, identifying their environment to their spontaneous cognitions. This view is supported by three lines of evidence.

First, reporting more verbal thoughts when one’s verbal working memory is supposedly impaired would go against well-established literature on the irrelevant sound effect.

Second, reporting less verbal thought when one has also reported more meta-awareness would be a marginal contradictory result compared to the accumulated evidence in the three previous experiments presented in this report that tend to show that inner speech is a tool for meta-awareness.

Third, it seems more than plausible that one that has no idea of what form to report would report what he/she is presented with. Hence, a report of more inner speech when one is listening to reversed speech (compared to white noise) constitutes a suspicious coincidence.

In summary, Experiment 4 replicated the main result of the other experiments and allowed to contrast consistent introspection of mindwandering and meta-awareness with the inconsistency of phenomenological reports.
General Discussion & Conclusion

This Masters project aimed at testing a two-fold hypothesis: that inner speech is a tool that helps gain meta-awareness of one’s mindwandering, and that mindwandering is close in phenomenology to mental images.

Logically, we anticipated that effects of conditions on reported phenomenology would mediate effects of conditions on mindwandering meta-awareness. However, none of the four experiments presented such mediation.

All experiments revealed a significant effect of meta-awareness on the condition which inner speech was supposed to be manipulated. Articulatory suppression and Reversed Speech led to significant decreases in the meta-awareness of mindwandering episodes, and a low picture/word ratio and stereotype threat led to significant increases in the meta-awareness of mindwandering episodes. These results based on very different literatures (cognitive psychology (Exp. 1, social psychology (Exp. 3), applied psychology (Exp.4) and even an original suggestion (Exp2)) have brought converging evidence that inner speech does play a role in meta-awareness of mindwandering.

As for the relation between mindwandering and mental images, no significant effect of any manipulation of mental images has been found on either meta-awareness or mindwandering. However, experiment 1, 2 and 3 found converging evidence that mindwandering was prominently related to both mental images and daily life propensity to use imaging thinking. This therefore gives further support to the Smallwood et al. (2004) suggestion that mindwandering would share similarities with mental imagery, with the double advantage that this support comes from both assessment of their cognitive habits and from direct introspective sampling of participants inner experience.

From a wider point of view, these experiments question the very human capacity of introspection. Introspection has strict limits: one cannot always introspect his mental processes (Nisbett & Wilson, 1977) because one is easily biased by his memory and peak and recency effects (Kahneman et al. 1993) or even by limits in conscious processing, as exemplified with the psychological refractory period (Corallo et al. 2008). Although thought-sampling has been used for decades (Klinger & Cox, 1987-88; Hurlburt & Schwitzgebel, 2007), this study highlights a striking contrast between the stability of the introspection of mindwandering and meta-awareness, and the inconsistency of phenomenological reports. In fact, phenomenological reports have such an wide variance, and can be so easily biased, that they may contradict well-established literature that is supposed to predict them. On the contrary, mindwandering and meta-awareness reports regularly fitted the Cheyne et al. (2009) model using a simple go/no-go task, and Experiment 3 further added that there was no obvious difference between mindwandering and meta-awareness assessed either via spontaneous thought-reports or via external thought reports.

In conclusion, this Master project proposes a role of inner speech in the distinction between zoning out and tuning out. However, the very mechanisms of this role – is language particularly salient? Does it have a structuring role in the extraction of thoughts? – are still to be explored. The tuning-out/zoning out distinction in itself has to be further studied given its possible importance in the very monitoring of mindwandering, and in respect to its contribution to the understanding of human consciousness.
References


APPENDICES

Contents :

- Experiment 1 graphics
- Experiment 2 & 3 graphics
- Experiment 4 graphics

- Experiment 2 stimuli (pictures from : [http://cvcl.mit.edu/MM/](http://cvcl.mit.edu/MM/))

- Experiment 2, 3 and 4 : Grebot’s French edition (2000) of the Individual Differences Questionnaire

- Experiment 3: Details of the Instructions
Experiment 1: Graphics indicating predicted decrease in Meta-awareness of mindwandering.

Experiment 1:
Increase of markers of tuning out (a) and of markers of zoning out (b) and decrease of self-caught off-task reports (c) during articulatory suppression, indicating a specific decrease of meta-awareness.
EXPERIMENT 2 and 3: Graphics indicating predicted increases in Meta-awareness of mindwandering

**Experiment 2**: Specific increase of off-task meta-awareness due to a high word/picture ratio

**Experiment 3**: Specific increase of off-task meta-awareness due to a Stereotype Threat manipulation

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EXPERIMENT 4: Mirror graphics indicating a predicted decrease in Meta-awareness of mindwandering

**Experiment 4**: Increase of markers of zoning out (a) and decrease of meta-aware mindwandering (b) in indicating a specific decrease of meta-awareness in high auditory noise compared to low auditory noise specifically.
EXPERIMENT 2 - Table of the 48 stimuli. The red frame indicates a set of possible targets.

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- F1: “verbal habits”, F2: “imaging habits”,
- F3 “care for verbal correctness”, F4 “daydreaming habits”.

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<td>Je n'ai pas de difficulté à m'exprimer verbalement</td>
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<td>Écrire une dissertation est pour moi quelque chose de difficile</td>
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<td>En formant l'image visuelle des éléments d'un problème, je parviens plus souvent à en trouver la solution</td>
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<tr>
<td>10</td>
<td>Lorsque mon esprit vagabonde, mes rêveries sont parfois si vives que j'ai l'impression de vivre une scène réelle</td>
<td>F4</td>
</tr>
<tr>
<td>11</td>
<td>J'utilise fréquemment des images visuelles pour trouver la solution d'un problème</td>
<td>F2</td>
</tr>
<tr>
<td>12</td>
<td>J'aime lire une histoire intéressante même si elle n'est pas particulièrement bien écrit</td>
<td>F3</td>
</tr>
<tr>
<td>13</td>
<td>Lorsque j'écris, j'ai du mal à trouver des synonymes</td>
<td>F1</td>
</tr>
<tr>
<td>14</td>
<td>J'ai des difficultés à m'exprimer par écrit</td>
<td>F1</td>
</tr>
<tr>
<td>15</td>
<td>Ma connaissance et ma pratique de la grammaire sont encore insuffisantes</td>
<td>F4</td>
</tr>
<tr>
<td>16</td>
<td>Je préfère travailler avec des idées plutôt qu'avec des mots</td>
<td>F3</td>
</tr>
<tr>
<td>17</td>
<td>J'aime apprendre des mots nouveaux et enrichir ainsi mon vocabulaire</td>
<td>F3</td>
</tr>
<tr>
<td>18</td>
<td>Je n'ai pas une imagination très vive</td>
<td>F4</td>
</tr>
<tr>
<td>19</td>
<td>Il m'est facile de me représenter mentalement des objets en mouvement</td>
<td>F2</td>
</tr>
<tr>
<td>20</td>
<td>Lorsque je lis un ouvrage littéraire, je suis davantage attentif au style de l'écriture qu'au contenu du texte</td>
<td>F3</td>
</tr>
<tr>
<td>21</td>
<td>Je peux former des images mentales pour pratiquement n'importe quel mot</td>
<td>F2</td>
</tr>
<tr>
<td>22</td>
<td>Je ne conserve que de vagues impressions visuelles des scènes que j'ai vue récemment</td>
<td>F2</td>
</tr>
<tr>
<td>23</td>
<td>Mon vocabulaire n'est pas aussi étendu que je le souhaiterais</td>
<td>F1</td>
</tr>
<tr>
<td>24</td>
<td>Je peux facilement trouver des synonymes de mots</td>
<td>F1</td>
</tr>
<tr>
<td>25</td>
<td>La pensée de la plupart des gens est faite d'images visuelles, même si elles ne s'en rendent pas toujours compte</td>
<td>F2</td>
</tr>
<tr>
<td>26</td>
<td>Je suis capable d'exprimer clairement ma pensée</td>
<td>F1</td>
</tr>
<tr>
<td>27</td>
<td>Je me souviens mieux des choses que j'ai faites moi-même que des choses que j'ai vues</td>
<td>F1</td>
</tr>
<tr>
<td>28</td>
<td>J'ai des capacités d'imagination au-dessus de la moyenne</td>
<td>F4</td>
</tr>
<tr>
<td>29</td>
<td>Je considère que j'ai une vitesse de lecture élevée</td>
<td>F1</td>
</tr>
<tr>
<td>30</td>
<td>Je possède un vocabulaire étendu</td>
<td>F1</td>
</tr>
<tr>
<td>31</td>
<td>Cela m'ennuie de voir un mot employé de façon impropre</td>
<td>F3</td>
</tr>
<tr>
<td>32</td>
<td>Écrire un texte, comme un devoir ou une dissertation est pour moi quelque chose de facile</td>
<td>F1</td>
</tr>
<tr>
<td>33</td>
<td>Je préfère avoir la description verbale d'un objet plutôt que leur photographie</td>
<td>F2</td>
</tr>
<tr>
<td>34</td>
<td>En fermant les yeux, il m'est facile de me représenter une scène que j'ai vécue</td>
<td>F2</td>
</tr>
<tr>
<td>35</td>
<td>J'ai une mémoire que l'on peut dire photographique</td>
<td>F2</td>
</tr>
<tr>
<td>36</td>
<td>Je pense qu'un dessin vaut mieux que mille mots</td>
<td>F3</td>
</tr>
<tr>
<td>37</td>
<td>Lorsqu'on me raconte une anecdote, je me représente les événements par l'imagination de manière très vive</td>
<td>F2</td>
</tr>
<tr>
<td>38</td>
<td>Lorsque j'entends ou que je lis un mot toute une série d'autres mots me viennent à l'esprit</td>
<td>F1</td>
</tr>
<tr>
<td>39</td>
<td>Je rêve peu</td>
<td>F4</td>
</tr>
<tr>
<td>40</td>
<td>Je lis plutôt lentement</td>
<td>F1</td>
</tr>
<tr>
<td>41</td>
<td>En général, dans un devoir ou une lettre, je suis capable de formuler du premier jet ce que je veux dire</td>
<td>F1</td>
</tr>
<tr>
<td>42</td>
<td>Je suis assez habile à faire des jeux de mots</td>
<td>F1</td>
</tr>
<tr>
<td>43</td>
<td>Je n'utilise jamais d'images mentales visuelles pour résoudre un problème</td>
<td>F2</td>
</tr>
<tr>
<td>44</td>
<td>Fréquemment, je me souviens de quelque chose que j'ai lu dans un livre en me représentant la page où je l'ai lu</td>
<td>F3</td>
</tr>
<tr>
<td>45</td>
<td>Étudier l'usage et la signification des mots est une activité qui m'est devenue familière</td>
<td>F3</td>
</tr>
<tr>
<td>46</td>
<td>Je dis ou j'écris ce qui me vient à l'esprit sans me soucier beaucoup du choix de mes mots</td>
<td>F3</td>
</tr>
<tr>
<td>47</td>
<td>Il n'y a pas assez de gens qui font attention à la manière dont ils s'expriment</td>
<td>F3</td>
</tr>
<tr>
<td>48</td>
<td>J'ai des difficultés à former l'image mentale visuelle du moindre objet</td>
<td>F2</td>
</tr>
<tr>
<td>49</td>
<td>Mes rêves sont extrêmement vivants</td>
<td>F4</td>
</tr>
<tr>
<td>50</td>
<td>Dans l'utilisation du langage, j'ai des capacités au-dessus de la moyenne</td>
<td>F1</td>
</tr>
<tr>
<td>51</td>
<td>Je lis beaucoup</td>
<td>F1</td>
</tr>
<tr>
<td>52</td>
<td>Je suis constamment attentif à la structure des phrases</td>
<td>F3</td>
</tr>
<tr>
<td>53</td>
<td>Mes pensées sont souvent constituées d'images visuelles</td>
<td>F2</td>
</tr>
<tr>
<td>54</td>
<td>Je ne forme aucune image visuelle des personnes et des lieux dont il est question dans mes lectures</td>
<td>F2</td>
</tr>
<tr>
<td>55</td>
<td>J'ai souvent des difficultés à expliquer les choses à mes interlocuteurs</td>
<td>F1</td>
</tr>
<tr>
<td>56</td>
<td>Dans la journée, mes rêveries sont plutôt vagues et imprécises</td>
<td>F4</td>
</tr>
<tr>
<td>57</td>
<td>J'apprécie souvent de retrouver un souvenir grâce à des images mentales</td>
<td>F2</td>
</tr>
<tr>
<td>58</td>
<td>J'utilise souvent des images mentales visuelles lorsque j'ai quelque chose à retenir</td>
<td>F2</td>
</tr>
<tr>
<td>59</td>
<td>Lorsque je reconstitue un événement passé, j'utilise des descriptions verbales plus que des images visuelles</td>
<td>F2</td>
</tr>
<tr>
<td>60</td>
<td>Lorsque je parle ou j'écris, je prends beaucoup de soin à m'exprimer avec précision et justesse</td>
<td>F3</td>
</tr>
<tr>
<td>61</td>
<td>L'utilisation correcte des mots est d'une importance secondaire par rapport aux idées exprimées</td>
<td>F3</td>
</tr>
<tr>
<td>62</td>
<td>J'ai une meilleure mémoire des choses que j'ai lues que des choses que j'ai vécues</td>
<td>F2</td>
</tr>
<tr>
<td>63</td>
<td>Les gens qui se chicanent sur l'usage des mots m'ennuient</td>
<td>F3</td>
</tr>
<tr>
<td>64</td>
<td>J'ai du mal à faire des associations à partir des mots que j'entends ou je lis</td>
<td>F1</td>
</tr>
<tr>
<td>65</td>
<td>Souvent il me vient des idées que j'ai du mal à exprimer verbalement</td>
<td>F1</td>
</tr>
<tr>
<td>66</td>
<td>Juste au moment de m'endormir, je me remémore en images les événements que j'ai vécus dans la journée</td>
<td>F4</td>
</tr>
<tr>
<td>67</td>
<td>Je préfère lire les consignes expliquant comment faire plutôt que d'assister à une démonstration</td>
<td>F1</td>
</tr>
<tr>
<td>68</td>
<td>Je suis un bon raconteur d'histoires</td>
<td>F1</td>
</tr>
<tr>
<td>69</td>
<td>Je consacre très peu de temps à essayer d'enrichir mon vocabulaire</td>
<td>F3</td>
</tr>
</tbody>
</table>
EXPERIMENT 3 – Details of the Instructions

One of the first things the experimenter told the participants was the condition related context. Instructions for all participants were the following:

"Bonjour. Merci de participer à notre expérience. Nous nous intéressons à l'attention soutenue. Comme vous le savez peut-être, la capacité à pouvoir se concentrer pendant plusieurs heures sans s'interrompre est cruciale pour les performances scolaires et professionnelles. Cependant, peu de choses sont encore connues sur les processus sous-tendant cette capacité. Cette recherche vise à mieux comprendre comment certaines personnes peuvent mieux se concentrer que d'autres."

The control group was then told:

"Votre performance en concentration d'aujourd'hui sera comparée avec d'autres étudiants."

Whereas the Stereotype Threat group was told:

"Comme vous le savez peut-être aussi, les jeunes adultes se plaignent de plus en plus de déficits attentionnels, déficits qui ne sont pas présents chez la génération précédente. La recherche confirme cette tendance, les jeunes adultes se déconcentrereraient plus souvent que leurs ainés dans une tâche d'attention soutenue.

Si des explications sociétales sont disponibles (un certain rôle des nouvelles technologies), les explications cognitives manquent. L'expérience à laquelle vous participez vise justement à comprendre ces processus cognitifs. Votre performance en concentration d'aujourd'hui sera comparée à celle d'adultes plus âgés (entre 30 et 45 ans).

La question est: le déficit attentionnel existe-t-il pour toutes les tâches d'attention soutenue, ou seulement pour certaines ?"

And the Public Speaking Threat was told:

"Ici, nous faisons l'hypothèse que ces capacités d'attention soutenue pourraient être liées avec des capacités intellectuelles plus larges, telles que l'intelligence ou les capacités sociales. Ainsi, votre performance en concentration d'aujourd'hui sera comparée à votre performance dans une tâche de présentation orale que vous ferez dans le dernier quart d'heure de l'expérience. Un sujet vous sera alors donné et vous aurez 5 minutes pour préparer une présentation rapide (moins de 10 minutes) devant deux de mes professeurs. Ceux-ci prendront des notes sur votre performance et votre personnalité, tout en ignorant votre score en attention pour ne pas être biaisé."

All participants were then presented with the functioning of the SART and of the thought-probe. Also, depending on the part, the selfcaught possibility or the awareness scale was mentioned.

Finally, the instructions were concluded with a reminder of the public speaking threat. All participants were told:

"Voici donc le plan de l'expérience : vous ferez cette tâche d'attention en deux fois (Partie I et II)."

Sentence that continued with the control and stereotype threat group as follows:

"Puis on conclura l'expérience avec un rapide questionnaire de personnalité (Partie III)."

Whereas for the public speaking threat group it continued as follows:

"Puis on vous apportera le sujet à préparer pour votre présentation et vous passerez ensuite dans une des salles voisines où les deux professeurs vous attendront (Partie III)."