Origin and Control of Persistent Mental Content

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Abstract

We often find that concepts or memories, especially regarding situations or social interactions, become "stuck in our heads". Such persisting content shapes our mental context and thereby our thoughts and actions. Yet, we know little about the cognitive and memory processes involved in the persistence of mental content. Do persisting thoughts depend on information maintained in working memory? To investigate this, we used a narrative reading paradigm which induces persisting thoughts. The rate of unwanted thoughts decreased over the minutes following the narrative, largely robust to changes in interfering material. Thus, the persisting content was not stored in a capacity-limited working memory system. Additionally, participants were able to reduce, but not eliminate unwanted thoughts using volitional suppression. Altogether the experience of persisting thoughts appears to rely on non-volitional retrieval from a passive memory trace.

Keywords: persist; thought; narrative; volition;

Introduction

It is not uncommon for a thought or experience to become "stuck in our heads". For example, the content of a recently read story can influence subsequent thoughts for several minutes (Bellana, Mahabal, & Honey, 2022; Faber & D'Mello, 2018). Here we address two questions about this fundamental aspect of human experience: (i) How is persisting content maintained over time? and (ii) How can it be controlled? It could be that persistent mental content is maintained in short-term memory (Cowan, 2017). For instance, individuals may hold aspects of a recent narrative within capacity-limited working memory systems that represent episodic or social information (Baddeley, 2000). If so, then it should be possible to interfere with the persistence of mental content by inserting new situational or social information into these working memory systems. And if persisting content cannot be blocked by interfering tasks, then is it subject to overt volitional control? In that case, simply instructing participants to suppress thoughts of a recent experience should eliminate their persistence.

Approach

To characterize the persistence of recent experiences on a participants' thought and behavior, we used the paradigm introduced by Bellana et al. (2022). Participants generated chains of words ("free association", Fig. 1C) before and after reading an immersive story (example in Fig. 1D). These words were later normed for "story-relatedness" from 1 (least) to 7 (most) by an independent group of participants. After free association, participants answered "to what extent did the story linger in your mind?" on a scale from 1 (least) to 7 (most).

Results

Narrative content persists in thought and behavior.

After reading the Intact story, individuals produced words related to the story (paired t-test on "story relatedness" Post-Pre: $t(82) = 4.41, p < .001, d = .48$; also see Fig. 1B). This semantic bias was absent when participants read the story with its word order randomly scrambled (Post-Pre $t(76) = -.31, p = .76, d = -.04$) (Bellana et al., 2022). Participants' report of subjective lingering was also higher following the Intact story than the Scrambled story (*Intact* $= 4.7$, *Scrambled* $= 2.6$, Kruskal-Wallis $H(1) = 51.6$, $p < .001$).

Persistent content is resistant to interference.

To test the role of social and situational working memory systems in the persistence of narrative content, we asked participants to perform a social or situational reasoning task for 30 seconds after they read the narrative, but before starting the second round of free association. In the "Pause" condition, participants waited for 30 seconds, holding the space bar. In the "theory of mind" condition, participants performed a false-belief task (Dodell-Feder et al., 2011). In the "Situation" condition, participants performed a situation reasoning task.

We found that none of the tasks reduced the story relatedness of generated words compared to the Intact condition without the task (Fig. 1E). Furthermore, participants report the same amount of lingering between all conditions (*Intact* $= 4.7$, *Pause* $= 4.8$, *Situation* $= 4.8$, *ToM* $= 4.9$, $H(3) = .91$, $p = .82$).

Persistent content is not volitionally eliminated.

We characterized how mental content re-enters our conscious thought over time, and we assessed whether these thought entries could be volitionally controlled. In this task, participants reported whenever a particular thought entered their mind by double-pressing the space bar. In the "Suppress"

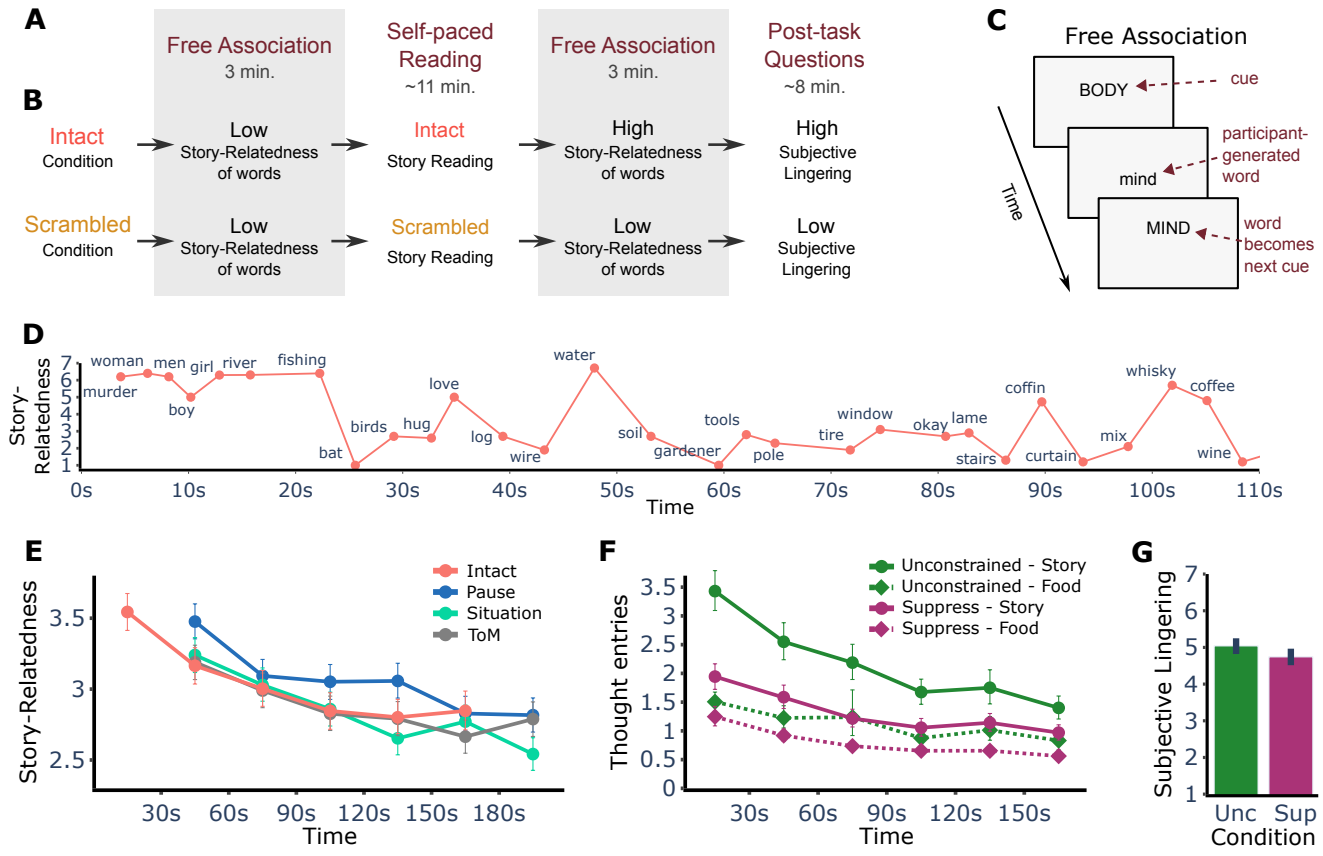

Figure 1: **A**: Experimental Paradigm with Schematic Results (**B**) from Bellana et al. (2022). Participants performed free association, read an Intact or Scrambled story, then performed free association again. Finally, they answered questions about the story and their subjective experience. **C**: Schematic of the chained free association task. **D**: First 110 seconds of a word chain a participant in the Intact condition produced after reading. **E**: Story-Relatedness did not decrease when individuals performed a 30 seconds long situational or social reasoning task, or when they paused for 30 seconds. **F**: Number of story-related and food-related thoughts that participants reported for the Unconstrained and Suppress conditions.**G**: Mean subjective lingering in Unconstrained and Suppress conditions. Error bars depict 95%CI, $n = 5000$.

condition, participants ($n = 162$) were instructed to *not think* about the story after reading it, but to button-press whenever the thoughts occurred (e.g. Wegner, Schneider, Carter, & White, 1987). Similarly, participants were instructed to not think about "food" in the free association phase before reading. In the "Unconstrained" condition, participants ($n = 160$) reported story/food-related thought entries, but without any instruction to suppress.

The instruction to suppress reduced persistent thoughts, but did not eliminate them. The number of story-related thought entries was greater in the Unconstrained than in the Suppress condition (*Unconstrained* $= 13.14$, *Suppress* $= 8.01$, Kruskal-Wallis $H(1) = 27.65$, $p < .001$). However, in both conditions the amount of thought entries decreased over time (Fig. 1F). Moreover, participants subjective reports of lingering were equivalent across conditions (*Unconstrained* $= 5$, *Suppress* $= 4.7$, Kruskal-Wallis $H(1) = 2.52$, $p = .11$, Fig. 1G). Importantly, participants were highly motivated to suppress, because they entirely eliminated the story-relatedness of words generated after the narrative (Post-Pre, $t(161) = .37, p = .71, d = .03$).

Discussion

We set out to understand how persisting content is maintained over time and how it can be controlled. Narrative content persisted in participants' thoughts and biased their behavior robustly, even when the narrative was immediately followed by a social or situational reasoning task. The lack of interference suggests that persisting content was not stored in a capacity-limited working memory store, nor as an active representation of situational or social information. Although thought entries were reduced by volitional suppression, they were not eliminated, and participants reported a comparable subjective lingering. We conclude that the influence of persistent content on thought does not originate in short-term memory systems and is resistant to volitional control.

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