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Harnessing the wandering mind: The role of perceptual load

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ABSTRACT

Perceptual load is a key determinant of distraction by task-irrelevant stimuli (e.g., Lavie, N. (2005). Distracted and confused?: Selective attention under load. *Trends in Cognitive Sciences, 9*, 75–82). Here we establish the role of perceptual load in determining an internal form of distraction by task-unrelated thoughts (TUTs or "mind-wandering").

Four experiments demonstrated reduced frequency of TUTs with high compared to low perceptual load in a visual-search task. Alternative accounts in terms of increased demands on responses, verbal working memory or motivation were ruled out and clear effects of load were found for unintentional TUTs. Individual differences in load effects on internal (TUTs) and external (response-competition) distractors were correlated. These results suggest that exhausting attentional capacity in task-relevant processing under high perceptual load can reduce processing of task-irrelevant information from external and internal sources alike.

1. Introduction

A main goal of attention research is to understand the determinants of successful focused attention that allows for minimal distraction by goal-irrelevant information. This fundamental issue has stimulated much research over the past four decades (e.g., see Kahneman and Treisman (1984), Lavie and Tsal (1994), Lavie (1995) for reviews) and a major determinant of focused attention that has been highlighted is the level of perceptual load in a task. The role of perceptual load in attention has been elucidated within the perceptual load theory (Lavie, 1995; Lavie & Tsal, 1994), which suggests that distractor processing critically depends on the availability of attentional capacity and can thus be prevented when the relevant-task processing involves sufficient high perceptual load to engage full attentional capacity.

Evidence in support of this claim has been found in many studies demonstrating that distractor processing is significantly reduced with tasks of high (compared to low) perceptual load (e.g., Lavie, 1995; Rees, Frith, & Lavie, 1997; see Lavie, 2005, for review). This conclusion has generalized across various manipulations of perceptual load (that have either involved a greater number of items requiring identification in the high load conditions or a greater complexity of the perceptual task, see Lavie, 2005, for review) and across various measures of distractor processing. For example, perceptual load has been shown to reduce (and indeed typically eliminate) distractor interference effects measured with response competition (Lavie, 1995; Lavie & Cox, 1997; Lavie, Ro, & Russell, 2003) and negative priming (Lavie & Fox, 2000). Perceptual load has also been shown to modulate brain activity related to distractors whether these are visible (Rees et al., 1997; Schwartz et al., 2005; Yi, Woodman, Widders, Marois, & Chun, 2004) or even invisible (Bahrami, Lavie, and Rees, 2007).

Recent studies have demonstrated that perceptual load effects can overcome individual differences in distractibility (Forster & Lavie, 2007) and can also eliminate the effects of highly salient distractors that, like many daily life distractors, cause interference despite bearing no relationship to the task currently being performed (Forster &

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Lavie, 2008a; Forster & Lavie, 2008b). However, in daily life sources of distraction may not only be found in the external environment, but also in the form of internally generated distractions such as task-unrelated thoughts (TUTs). For example, a person may be distracted from reading this article by the intrusion of a thought about an unrelated issue - perhaps some salient recent event in his or her daily life. The purpose of this paper is to clarify whether the established role of perceptual load in determining task-irrelevant processing would also apply to internal sources of potential distraction, such as distraction by TUTs.

We reasoned that, similarly to the role of load in processing task-irrelevant information from external sources, the processing of task-irrelevant information from internal sources such as mind-wandering may also be determined by perceptual load. The load research we previously mention has established that processing of task-irrelevant stimuli with very different contents (e.g., verbal vs. visual and complex stimuli such as words or visual scenes vs. simple stimuli such as letters or contrast and motion, Brand-D'Abrescia & Lavie, 2007; Lavie, 2006; Macdonald & Lavie, 2008; Rees et al., 1997; Schwartz et al., 2005) and sources (e.g., different sensory modalities, conscious as well as unconscious processes, e.g., (Bahrami, Carmel, Walsh, Rees, & Lavie, 2008; Cartwright-Finch & Lavie, 2006; Dalton, Lavie, and Spence, 2008; Macdonald & Lavie, 2008) is modulated by the level of load in the task-relevant processing. These findings provide support for the Load Theory claim that the processing of any task-irrelevant information (be it verbal or visual, simple or complex, conscious or unconscious, in one sensory modality or another, and so forth) requires limited-capacity attention and can therefore occur only when the processing of task-relevant information leaves some spare attentional capacity (under conditions of low perceptual load). We thus reasoned that higher perceptual load that would engage more attentional capacity in the processing of task-relevant information may reduce the processing of task-irrelevant information not only from external sources (e.g., visual distractors) but also from internal sources (e.g., mind-wandering) in the present study.

1.1. Mind-wandering measures and previous findings

In comparison to the extensive body of research examining the attention principles that govern distraction by external stimuli, the topic of attention and distraction by mind-wandering has been relatively understudied, perhaps due to lack of any truly objective method for directly measuring the occurrence of such a highly subjective phenomenon. However, laboratory measures of mind-wandering have been developed (e.g., measuring TUT occurrence with probe-caught methods, whereby on the appearance of a probe the subject has to report whether or not they had just experienced TUT), and studies using these methods suggest that mind-wandering is a ubiquitous and potent source of distraction: TUTs often occur unintentionally and interfere with performance on a range of tasks from signal detection tasks to encoding and reading tasks (Schooler, Reichle, & Halpern, 2004; Segal & Fusella, 1970; Smallwood, Baracaia, Lowe, & Obonsawin, 2003; Smallwood, O'Connor, Sudberry, Haskell, & Ballantyne, 2004; Smallwood, McSpadden, & Schooler, 2007; see also Smallwood & Schooler, 2006; Smallwood, Fishman, & Schooler, 2007 for review).

Despite these apparent distracting effects of mind-wandering, however, no study as yet has demonstrated any causal role for focused attention in determining levels of TUT. A number of studies have directly manipulated task factors that were found to decrease the level of task-unrelated thoughts,[1] but none has yet used an established manipulation of focused attention. Moreover, in almost all cases these manipulations are likely to have interfered directly with the very ability to produce or maintain a thought. Thus the role of focused attention in TUTs (or mind-wandering) remains unclear.

For example, it has been shown that working memory load can reduce TUT (Teasdale et al, 1995; Teasdale, Proctor, Lloyd, & Baddeley, 1993), yet working memory is clearly needed in order to provide a mental work space for thought (for example one would need to maintain the start of the thought in order to develop its semantics in a coherent manner in which the end relates to the start, see Baddeley (1986)). It has also been shown that performing a task relative to no task at all or increasing stimulus presentation rates can reduce the rates of TUT reports (e.g., Giambra, 1995; McKiernan, D'Angelo, Kaufman, & Binder, 2006). However, not only do conditions of task performance (compared to no task performance) and faster (vs. slower) presentation rates involve a higher working memory load, but they also involve increased demands on responses (as with higher presentation rate the response rate is also higher). The simple act of making a response has been shown to directly interfere with the rate of TUT reports (e.g., see Antrobus (1968)). By contrast, here we ask whether it is possible to reduce task-unrelated thoughts by engaging more attentional capacity in a task with high (compared to low) perceptual load, without directly drawing on thought or response components that are clearly part and parcel of the production or report of any thought.

The suggestion of a recent review of the mind-wandering literature that the rate of TUTs reported is higher in tasks that require only "superficial engagement" compared to those that require moderate or deeper levels of engagement (Smallwood, Fishman et al., 2007) is encouraging for our present load hypothesis. However, the broad term "task-engagement" may encompass a number of factors in addition to attention (e.g., changes in the overall level of motivation, interest and arousal, as well as the engagement of processes such as working memory and thought) and the tasks presumed in the review to involve differing levels of task engagement (e.g., signal detection tasks were assumed to involve superficial engagement, whereas reading tasks were assumed to always involve deep engagement) also differed in terms of many of these factors. Therefore any variation in the rate of TUTs reported during

[1] Note that we restrict our review only to manipulations that produced significant effects on the level of TUT reported.