Acta Psychologica 172 (2017) 49–54

Contents lists available at ScienceDirect

Acta Psychologica

journal homepage: www.elsevier.com/locate/actpsy

Mind wandering and the attention network system

Óscar F. Gonçalves [a,b,c,*], Gabriel Rêgo [c], Patrícia Oliveira-Silva [a,d], Jorge Leite [a,b], Sandra Carvalho [a,b], Felipe Fregni [b], Edson Amaro Jr [e], Paulo S. Boggio [c]

[a] Neuropsychophysiology Lab - CIPsi, School of Psychology, University of Minho, Braga, Portugal
[b] Spaulding Neuromodulation Center, Department of Physical Medicine & Rehabilitation, Spaulding Rehabilitation Hospital and Massachusetts General Hospital, Harvard Medical School, Boston, USA
[c] Social and Cognitive Neuroscience Laboratory, Center for Health and Biological Sciences, Mackenzie Presbyterian University, São Paulo, Brazil
[d] Human Neurobehavioral Laboratory, Centre for Studies in Human Development (CEDH), Faculdade de Educação e Psicologia - Universidade Católica Portuguesa (FEP-UCP), Porto, Portugal
[e] Department of Radiology, Clinical Hospital, University of São Paulo School of Medicine, São Paulo, Brazil

ARTICLE INFO

Article history:
Received 11 February 2016
Received in revised form 11 November 2016
Accepted 18 November 2016
Available online 22 November 2016

Keywords:
Mind wandering
Attention
Alerting
Orienting
Conflict
Executive control

ABSTRACT

Attention and mind wandering are often seen as anticorrelated. However, both attention and mind wandering are multi-component processes, and their relationship may be more complex than previously thought. In this study, we tested the interference of different types of thoughts as measured by a Thought Identification Task - TIT (on task thoughts, task related interference thoughts, external distractions, stimulus independent and task unrelated thoughts) on different components of the attention network system - ANT (alerting, orienting, executive). Results show that, during the ANT, individuals were predominantly involved in task related interference thoughts which, along with external distractors, significantly impaired their performance accuracy. However, mind wandering (i.e., stimulus independent and task unrelated thoughts) did not significantly interfere with accuracy in the ANT. No significant relationship was found between type of thoughts and alerting, orienting, or executive effects in the ANT. While task related interference thoughts and external distractions seemed to impair performance on the attention task, mind wandering was still compatible with satisfactory performance in the ANT. The present results confirmed the importance of differentiating type of "out of task" thoughts in studying the relationship between though distractors and attention.

1. Introduction

In absence of a specific task demand, minds tend to wander. Even with external attention demands, the mind periodically escapes into space and time travel (Corballis, 2013). In neuroimaging research, tasks that activate brain regions associated with attention are often referred as task positive while tasks responsible for the activation of mind wandering are labeled as task negative (Fox et al., 2005). Task negative and task positive conditions are associated with contrasting brain networks, respectively Default Mode Network (DMN) and Dorsal Attention Network (DAN). Switching from a mind wandering mode to an attention mode requires DMN deactivation and the concomitant activation of the DAN (Mason et al., 2007). Consistently, brain oscillatory rhythms show an increased activity of slow rhythms (Theta and Delta) and a decrease of fast rhythms (Alpha and Beta) when individuals start mind wandering, drifting away from a current task (Braboszcz & Delorme, 2011).

Attention and mind wandering are often seen as anticorrelated. This conclusion is based on data showing that mind wandering tends to recruit executive resources that are necessary for the performance of attention tasks (Smallwood & Schooler, 2006). Several studies have associated mind wandering with failures in executive control (Kane & McVay, 2012). However, there is now evidence that mind wandering does not affect equally different executive tasks. For example, Kam and Handy (2014) observed that mind wandering negatively affects performance in working memory and response inhibition but not set-shifting tasks. Each of those executive tasks involves distinct psychological mechanisms (working memory - capacity to hold and update information online; response inhibition - inhibitory control over a pre-potent response; set-shifting - cognitive flexibility for applying new rules to solve the same task).

Interestingly, a neuroimaging study by Christoff, Gordon, Smallwood, Smith, and Schooler (2009) showed that mind wandering tends to recruit not only the DMN but also brain networks associated with executive functioning. Therefore, it is possible that at least some types of mind wandering may not only compete but also facilitate some attention processes by recruiting complementary brain networks (e.g., DMN) that help with processes such as attention recycling, dishabituation or mood regulation (Smallwood & Schooler, 2015).

* Corresponding author at: Northeastern University, Counseling and Applied Educational Psychology, 360 Huntington Avenue, 02115 Boston, MA, USA.
E-mail address: o.goncalves@neu.edu (Ó.F. Gonçalves).

http://dx.doi.org/10.1016/j.actpsy.2016.11.008
0001-6918/

Recent studies showed that the relationship between mind wandering and attention is more complex than previously thought and may require to approach both attention and mind wandering as multicomponent processes (Peterson & Posner, 2012; Stawarczyk, Majerus, Catale, & Argembeau, 2014).

>30 years ago, Michal Posner introduced what is probably the most influential model of attention (Posner & Petersen, 1990). According to this model, there are at least three key functionally and anatomically distinct types of attention processes: alerting, orienting, and executive control. Alerting is defined as the process of reaching and maintaining a state of responsiveness to external stimuli. Orienting refers to the ability to select among multiple stimuli. Finally, executive control refers to the executive monitoring of performance and is mostly involved in goal-directed behaviors that requires, among others, decision making, error detection, and novel responses. These networks have been systematically assessed using the Attention Network Test (Macleod et al., 2010). Research shows that these three attentional components are supported by different neuroanatomical networks (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005), and are associated with distinct genetic profiles (Fossella et al., 2002).

Mind wandering, like attention, is a multidimensional process. According to Schooler et al. (2011), mind wandering involves decoupling from attention to external stimuli and engaging in thought flow. While most of the studies have relied on a dichotomic classification (attention versus mind wandering), several authors differentiate among several "out of task" thoughts usually subsumed under the concept of mind wandering. Stawarczyk et al. (2011a) suggested three different types of "out of tasks thoughts" during attention external demands: task-related interference thoughts (TRI), external distractions thoughts (ED), and stimulus independent and task unrelated thoughts (SITUT). TRI refers to thoughts that are associated with side aspects of the task being performed, and are therefore concerned with performance, duration, level of difficulty, etc. ED includes thoughts about environmental stimuli irrelevant for the task, namely: heat, noise, discomfort, hunger, etc. Finally, the typical mind wandering experience is constituted by SITUT in which the mind is dissociated from both the task and external stimuli. All these thoughts contrast with on task thoughts (OT - task-related and stimulus-dependent thoughts). Several studies suggest that these different type of thoughts can predict performance in a variety of cognitive tasks (Stawarczyk et al., 2014) and are characterized by distinctive neural networks (Stawarczyk, Majerus, Maquet, & D'Argembeau, 2011).

Several studies explored the relationship between attention and mind wandering, looking at different components of attention and mind wandering. For example, Hu, He, and Xu (2012) examined the relationship between the three components of the ANT (alerting, orienting and conflict) and mind wandering. In their study, mind wandering was directly measured through thought probes and, indirectly, by performance indexes in the Sustained Attention to Response Task (SART). More specifically, while responding to SART, participants were requested to report their thoughts during 15 pseudorandom probes by selecting one among three options: task (i.e., thoughts associated with the stimuli being presented and responses); task performance (i.e., thoughts regarding their own performance); something else unrelated to the task (i.e., irrelevant thought intrusions). Additionally, several SART measures were selected as indirect behavioral indexes of mind wandering: (e.g., reaction time variability, anticipations, and omissions). The authors found that mind wandering was negatively associated with the orienting network, as measured directly by the thought probes and indirectly by the correlation with SART indexes. No additional significant relationships were found between mind wandering and the other components of the ANT.

Stawarczyk et al. (2011a), on the contrary, looked at the relationship between different type of thoughts and attention as measured by the SART. In this study, each SART block was followed by thought probes requiring the participant to classify their thoughts in the previous block according to one of the thought categories described above (i.e., OT, TRI, ED, SITUT). The authors found that different types of thoughts have a different profile of impact on the attention task. SITUT, ED, and TRI significantly interfered on SART performance. However, the total number of TRI did not correlate significantly with SART performance and, contrary to ED and SITUT, frequency of TRI did not increase with task duration.

Unsworth and McMillan (2014) researched the relationship between two types of task unrelated thoughts (i.e., external distractions and mind wandering) and three cognitive variables (i.e., attention control, working memory, and fluid intelligence) as assessed by a variety of experimental tasks (e.g. SART, Arrow Flankers, Stroop, Operation Span, Reading Spam, and Raven Advanced Progressive Matrices). The results of latent variable analysis showed that external distractions and mind wandering (i.e., "I am zoning out/my mind is wandering") are different factors (even though correlated) and individuals with less attention control are more prone to both external distractors and mind wandering. Additionally, the authors found that lapses of attention, as expressed both by external distractions or mind wandering, were associated with individual differences in working memory capacity and fluid intelligence.

A more recent study by Robison and Unsworth (2015) confirmed that external distractions and mind wandering differentially impacts performance. While both types of thoughts negatively impact performance, individuals' executive abilities (e.g., working memory capacity) were found to mediate resistance to mind wandering in a silent condition (i.e., silent study environment) and resistance to external distraction in the noise condition (i.e., noisy study environment) during a reading comprehension task.

Studies with noninvasive brain stimulation techniques have also provided insights about the causal relationship between mind wandering and attention. Axelrod, Rees, Lavidor, Bar, and Corballis (2015) found that left dorsolateral prefrontal cortex (DLPFC) stimulation with transcranial direct current stimulation (tDCS) increased mind wandering. Interestingly, instead of a deleterious effect on external task performance, the authors found a small improvement on SART.

The results of the research reported above suggest a complex interaction between different types of mind of thoughts (e.g., ED, TRI, SITUT), type of task (e.g., inhibitory control, set-shifting), cognitive abilities (e.g. working memory, fluid intelligence), and contexts (e.g., silent versus noisy environments).

In sum, there is evidence that interference of mind wandering in attention tasks can either be facilitative or detrimental (Randall, Oswald, & Beier, 2013; Smallwood & Schooler, 2006) dependent on the interaction between category of mind wandering thoughts (e.g., Stawarczyk's taxonomy) and type of attention task (e.g., Posner's ANT components). Therefore, the objective of this study is to test the relationship between different types of mind wandering thoughts and different components of the attention network system. More specifically, we aim to study if performance in the attention network test (alerting, orienting and executive) is associated with the predominant type of interfering thoughts reported online (On task - OT; Task related interference - TRI; External distractions - ED; Task-unrelated and stimulus-independent experience-SITUT).

2. Methods

2.1. Participants

The sample was constituted by 209 healthy college students (145 women, 64 men) with normal or corrected to normal vision. Their age ranged from 17 to 51 years, with a mean age of 20.94 years (SD = 4.99). All participants provided signed informed consent and the study was carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).