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When the mind flies: Tracking Mind Wandering across different domains of daily activities

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Contents

Abstract

Mind wandering (MW) represents a shift of attention away from the task at hand toward inner thoughts. It is commonly investigated by using thought sampling such as probe-caught and self-caught method. On the one hand, the probe-caught method requires that participants are probed at irregular intervals about their contents of mind during the execution of the task at hand explicating whether they were on task or not and providing details about their mental experience (for example explicating whether they were aware or not of their MW mental state). On the other hand, the self-caught method requires that participants refer spontaneously whenever they become aware of the discrepancy between contents of their thoughts and the task at hand. Several studies have shown that MW has a costly influence on a number of cognitive processes such as attention, reading comprehension, encoding, and even during daily life. This thesis explored the impact of MW in the domains of two daily activities, i.e., narrative discourse production and driving.

Study 1 comprehended Experiment 1 (see Chapter 2) and Experiment 2 (see Chapter 3) that are part of a wider research involving 65 participants. In Experiment 1 (see Chapter 2), the cognitive characteristics of MW episodes were investigated. A literature review of the scientific field highlighted the importance of a better understanding of MW nature. As first, the majority of the studies defined mental states as only on-task or off-task. However, growing evidence shows that MW can be better understood by differentiating among mental states. Given that, thought probes embedded in the Sustained Attention to Response Task (SART) allowed to define participants' mental

state by distinguishing depending on awareness, lacking of awareness, mind blanking, or thoughts related to performance quality. As second, the role played by Executive Functions on MW episodes is still debated and different theories (i.e., the decoupling hypothesis, and the executive failures hypothesis) are proposed in order to explain its occurrence. Accordingly to these considerations, the aim was to cognitively characterize different MW episodes. To do this, an extensive cognitive assessment (i.e., working memory updating, set shifting, inhibition, and attention) was administered. It is well known the model that explains the three components of the executive functions, namely the inhibition, the updating of working memory, and the set-shifting. However, considering the critical point of the task impurity problem of the tasks commonly used to assess executive functioning, a Principal Component Analysis (PCA) was performed in order to assess whether the components could be identified. The PCA allowed us to isolate a unique Executive Functioning component that was a significant positive predictor of the frequency of those MW episodes characterized by awareness.. On the other hand, this component approached to explain a significant part of the variance of frequency of those MW episodes characterized by lacking of awareness (with a negative relationship). Thus, Executive Functioning seems to play an opposite role in explaining meta-awareness of MW mental states.

Experiment 2 of the Study 1 (see Chapter 3) explored the relation between MW and narrative discourse production. About the narrative discourse production, a multi-level approach to discourse analysis was used allowing to obtain information about how effective and informative, from a communicative point of view, information provided is. This ability to provide the right information may represent an ability to stay on the narrative task inhibiting irrelevant or tangential information. Based on these considerations, the aims were to assess (1) whether the ability to stay on task during an attentional task (i.e., SART) and the ability to communicate effectively are related, and (2) whether it was possible to identify an index of derailment from the purpose of what it is being done which could be explained by a role played by Executive Functioning. To do this, a story-telling task was administered to obtain samples of narrative discourse that were analysed by using a multi-level approach to discourse analysis. As a preliminary step in the analysis, a PCA was performed on a set of narrative variables in order to examine the relation between microlinguistic and macrolinguistic aspects. Two components were extracted from the PCA: (a) Communicative Effectiveness, and (b) Effects of discourse flow interruption. As regard to the relationship between a wandering mind and narrative discourse production, of particular interest was the Communicative Effectiveness component. Indeed, a correlation analysis showed that this component was negatively correlated to the reaction times coefficient of variability (RTCV), a behavioural index of SART that mirrors the ability to stay on task (lower RTCV) or conversely the tendency to let the mind wander (higher RTCV). A further PCA was then performed to explore whether it was possible to isolate an index of derailment from the purpose of what it is being done. The results did not confirm the hypothesis, however the ability to effectively convey information was related to Executive Functioning and the lack of awareness of MW episodes (with a negative relation). Thus, the most efficient narrative samples were produced by those participants with greater executive resources that reported less frequently to be unaware of MW episodes underlying the necessity of being present in the here and now.

In Study 2 (see Chapter 4) the comparison between a probe-caught and a self-caught sampling procedure, embedded in a driving task, was presented with the aims of (1) exploring how MW affects driving performance depending on the sampling procedure used, and (2) exploring the frequency of MW. To do this, a lane-keeping task was administered to two groups, (17 participants in Probe-Caught group vs. 14 participants in Self-Caught group) to study the basic driving skills, as measured by mean speed, standard deviation of speed, standard deviation of steer, and standard deviation of lateral position. Speed and vehicle stability indices were recorded over a 10 seconds period prior to probe presentation, in the Probe-Caught group, or prior to the spontaneous button pressing, in the Self-Caught group (i.e., MW mental state) and from 10 to 20 seconds after (i.e., Full attention mental state). Each dependent variable was analysed by a 2 (Mental state: MW vs. Full attention) x 2 (Group: Probe-Caught vs. Self-Caught) ANOVA. Results showed that MW does not affect basic driving skills, and drew attention to the critical implications of different thoughts sampling methodology. Indeed, the self-caught procedure may be more suitable for studying the detrimental effect of MW on driving performance, whereas the probe-caught procedure can inform on the nature of strategic response to distraction derived from MW. Moreover, in both studies presented in Chapter 2 and Chapter 4 a MW increment with time on task was observed.

Study 3 (see Chapter 5) explored the impact of MW during everyday driving. The main aims were to investigate: (1) which contextual and emotional conditions are more likely to induce MW occurrence, (2) the influence of demographic variables on the frequency of MW, (3) the relation between MW and other types of common source of distractions behind the wheel. To do this, a new questionnaire was developed and was administered to 161 Italian drivers. Three components were extracted from a PCA, indicating three major sources of distraction, namely, (a) MW State, (b) Use of Technology, and (c) Environmental Distraction; these components were partially independent. As MW State component was highly correlated with MW frequency, a MW Scale was developed (Cronbach's alpha = .913) and taken into consideration for

further analysis. Younger drivers reported higher scores on this scale. Moreover, environmental distractions and the monitoring of attention, defined as the tendency to refer later MW episodes, increased scores on this scale. These findings suggest that frequency of MW does not rely on contextual or emotional conditions; rather, it can be considered as a general tendency to let the mind wander, more frequent in younger drivers.

Keywords: Mind wandering, Narrative skills, Driving skills, Questionnaire

Chapter 1

The what, when and why of Mind Wandering. A literature review

1.1 – Introduction to the notion of Mind Wandering

The term *mind wandering* (MW; Smallwood & Schooler, 2006) refers to a drifting of attention from the current task to inner thoughts that can be unrelated to the task at hand. This is an extremely frequent phenomenon. For example, by exploring MW frequency in 2,250 adults during their everyday life, Killingsworth and Gilbert (2010) showed that it occurred in almost half of waking hours. Hence, the comprehension of the characteristics of MW has gained in recent times more and more attention.

During the last few decades, many overlapping definitions of this experience have been provided including task-unrelated thought (Smallwood, Baracaia, Lowe & Obonsawin, 2003; Smallwood, Obonsawin & Heim, 2003), stimulus-independent thought (Antrobus, Singer & Greenberg, 1966), task-unrelated imagery and thought (Giambra, 1995). These definitions postulate that MW arises independently from what is perceived during the execution of an activity (i.e., it is task-unrelated and stimulus-independent). In addition to these definitions, Smallwood (2013) proposed the expression *self-generated thoughts* highlighting that such thoughts are not cued by external stimuli but arise from changes within the individual. Notably, both self-generated and perceptually guided thoughts can be either related or unrelated to the ongoing task (see Figure 1.1) (Smallwood & Schooler, 2015). Perceptually guided thoughts can be triggered by the activity as in Figure 1.1a where the person is so much focused on what she is doing that her contents of thought are perceptually guided by the task at hand. Furthermore, while performing a task an unrelated stimulus coming from the environment can trigger thoughts that can be defined as perceptually guided but unrelated to the task at hand (Figure 1.1b). The sound coming from the environment distracts momentarily the person determining a disengagement of attention cued by environmental stimuli from the ongoing activity. However, the disengagement of attention is due to perceptual stimuli rather than being due to self-generated mental contents. On the other hand, self-generated thoughts that are related to the task can take the form of considerations about the task at hand that are not necessary for its execution (Figure 1.1c). Finally, self-generated thoughts that are unrelated to the task are characterized by the disengagement of attention from the ongoing activity to other thoughts such as concerns, plans for the future, or memories (Figure 1.1d).

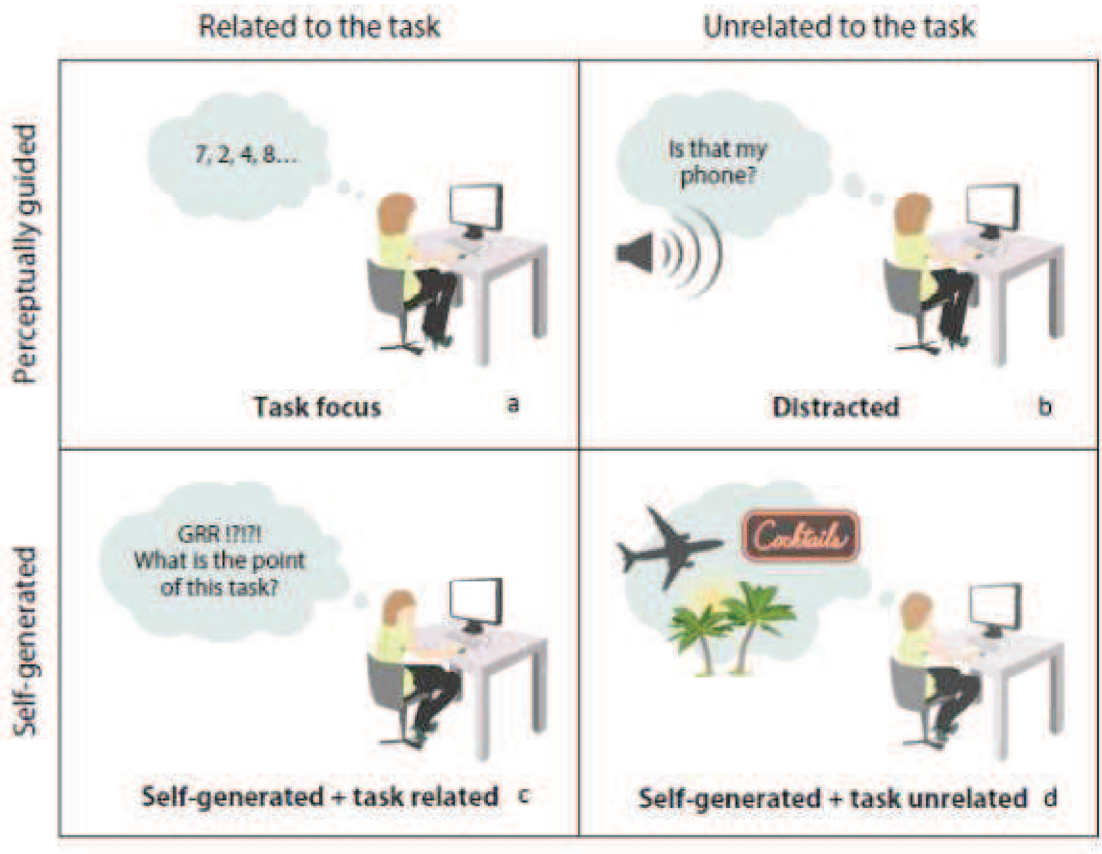

Figure 1.1 - Schematic representation of possible contents of mind during a task, from Smalwood & Schooler (2015)

1.2 – Methods of thought sampling

MW is commonly investigated using experience sampling techniques that allow to measure subjective experiences using probe-caught, self-caught, and retrospective methods (Smallwood & Schooler, 2006; 2015).

Probe-caught method requires that, during the execution of a task, participants are probed at irregular intervals about their contents of mind in the moment just before the probe presentation. The percentage of probes presented during the task varies from study to study. However, the frequency of MW episodes increases with larger inter-probe intervals (Seli, Carriere, Levene & Smilek, 2013). Moreover, probes presentation may catch the participants in a MW state characterized by lacking of awareness providing information about whole MW frequency; this may be considered the main characteristic of this sampling method. Thoughts may be classified by the participants themselves (self-classification) or by the experimenters (experimenter-classification). The former implies that, before the beginning of the task, participants are given a description of MW episodes so that during the task they can classify their thoughts by themselves. On the other hand, the experimenter-classification involves probes presentation asking participants to describe, by their own words, their train of thoughts just before probe presentation. In a second step, independent judges classify these thoughts (Baird, Smallwood & Schooler; 2011).

Self-caught method requires that, during a task, participants refer spontaneously whenever they become aware of the discrepancy between contents of their thoughts and the task at hand. Thus, this experience sampling method requires participants to be aware of their contents of their experience (Smallwood & Schooler, 2006) and this is one of the most important differences between probe-caught and self-caught methods.

Finally, retrospective methods do not interrupt the task at hand as participants are required to fill a post-task questionnaire such as the Thinking Content component of the Dundee Stress State Questionnaire (Matthews, Joyner Gililand, Campbell & Faulconner, 1999). This is frequently used (Smallwood, O'Connor, Sudberry, Haskell & Ballantyne, 2004; Smallwood, Fitzgerald, Miles & Phillips, 2009; Smallwood & O'Connor, 2011) for measuring two aspects of subjective reports: task unrelated thoughts (TUTs) (e.g., "I thought about personal worries" or "I thought about something that happened earlier today") and task related interference (TRI, Sarason, Sarason, Keefe, Hayes & Shearin, 1986) (e.g., "I thought about how I should work more carefully" or "I thought about my level of ability"). However, the negative side of the coin is that this method relies to a great extent on memory. Additionally, questionnaires can also be used to explore the occurrence of MW during everyday activities (e.g., during driving, Berthié et al., 2015).

1.3 – The contents of Mind Wandering

Using experience samplings techniques, several studies have explored the temporal orientation (i.e., thoughts about past, present or potential future events) of MW highlighting a prospective bias of MW episodes that usually concern anticipations or plans for the future (Baird et al., 2011; Smallwood, Nind & O'Connor, 2009; Stawarczyk, Majerus, Maj, Van der Linden & D'Argembeau, 2011). Smallwood, Nind and O'Connor (2009) observed that this prospective bias might be curtailed by task demands as prospection consumes a higher amount of working memory resources. The temporal focus of MW might also depend on the experience with the topic at hand when participants are not interested in the task, indeed individuals who rated greater experience about the topic tended to think about the past, whereas those who rated lower experience tended to think about the future. On the other hand, reading interesting texts reduces the occurrence of task-unrelated thoughts regardless of temporal focus. However, by including even an atemporal option, participants did not report of thinking about past or future events, rather about something that is difficult to define temporally, namely atemporal (Jackson, Weinstein & Balota, 2013).

As for the emotional valence (i.e., positive or negative connotation of such thoughts) of MW, studies have focused on tasks in the laboratory (Ruby, Smallwood, Engen & Singer, 2013; Smallwood & O'Connor, 2011; Stawarczyk, Majerus & D'Argembeau, 2013), but also on what happens in everyday life (Killingsworth & Gilbert, 2010; Poerio, Totterdell & Miles, 2013). Overall, the emotional valence of thoughts is apparently associated with mood. However, this association can be mediated by temporal aspects of thoughts. Specifically, by asking to report about the temporal orientation and current mood at the time of probe presentation, past-oriented thoughts are usually associated with negative mood, whereas future oriented ones with a mood increment (Ruby et al., 2013). Moreover, mood induction watching emotional videos allowed to observe that negative mood induction led to more errors during the Sustained Attention to Response Task (SART, Robertson, Manly, Andrade, Baddeley & Yiend, 1997) and higher frequency of task-unrelated thoughts (Smallwood, Fitzgerald et al., 2009) and to a retrospective bias associated with subsequent negative mood (Smallwood & O'Connor, 2011). Additionally, Stawarczyk and colleagues (2013) observed that the extent to which induced concern determines an affective response predicted the subsequent frequency of MW: more relevant concerns elicited more frequent states of MW. The affective characterization of thoughts was even associated with individual differences in wellbeing (Andrews-Hanna et al., 2013), indeed thoughts characterized as positive and less relevant from a personal point of view were related to an increment of wellbeing as measured by the Five Facet Mindfulness Questionnaire (Baer, Smith, Hopkins, Krietemeyer & Toney, 2006), whereas negative valence and personal relevance were associated with the construct of Depression/Negative Affect. Furthermore, negative mood led to lower performance characterized by more lapses of attention, more difficulty in re-engaging attentional resources, and higher frequency of task-unrelated thoughts and of thoughts concerning performance (Smallwood, Fitzgerald et al., 2009), whereas positive mood was more likely to determine a better performance adjustment after a lapse of attention. Considering these results, negative mood reduced attentional resource devoted to the task and this reduction might be due to the increment of attention directed to irrelevant thoughts such as personal concerns.

In addition, Franklin, Mrazek and colleagues (2013) observed an association between MW and lower mood. However, differentiating MW contents on the base of interest, usefulness, and novelty, thoughts rated as more interesting were associated with more positive mood. In addition to laboratory studies, the emotional valence of MW has been explored also during everyday life. Indeed, a large number of participants were recruited using an application for iPhone while they were carrying out daily activities. This experience sampling method allowed to observe that MW during daily life was associated with unhappiness, and this feeling was particularly prominent when MW episodes were past-oriented (Killingsworth & Gilbert, 2010). Similarly, Poerio and colleagues (2013) observed that sadness was associated with MW, and in particular with past-oriented thoughts. A recent study by Berthié and colleagues (2015) explored contents of MW during the last trip behind the wheel highlighting that the majority of thoughts reported involved private concerns, were future oriented, and were of neutral emotional valence. Self-generated thoughts may be considered either a cause (Killingsworth & Gilbert, 2010) or a consequence of negative affect (Smallwood, Fitzgerald et al., 2009; Smallwood & O'Connor, 2011; Stawarczyk et al., 2013).

1.4 – Cognitive underpinnings of Mind Wandering

Different hypotheses have been formulated in order to account for the cognitive underpinnings of MW. Among these, the current concern hypothesis, the decoupling hypothesis, the executive failure hypothesis, the context regulation hypothesis, and the meta-awareness hypothesis are some of the most debated.

1.4.1 – The current concerns hypothesis

According to the current concern hypothesis (Klinger, 1999; Klinger, Gregoire & Barta, 1973), MW episodes occur because people have their own goals that go beyond the activity that they are performing at the moment. Thus, when the environment provides few salient stimuli and the individual's thoughts are more relevant, self-generated thoughts arise and gain the focus of mental experience. At times, off-task thoughts may be even cued by the environment (Klinger, 2009).

The current concerns hypothesis can be used to integrate other hypotheses that have been formulated in more recent times. For example, according to the Control x Concerns hypothesis (an integration of the decoupling hypothesis [see §§1.4.2]; Smallwood & Schooler, 2006), current concerns might trigger automatically some thoughts about an individual's goals that, after having gained the focus of attention, will be ensured by executive control. On the other hand, the Control Failure x Concerns hypothesis (an integration of the executive failure hypothesis [see §§1.4.3]; McVay & Kane, 2010) posits that the relevance of personal concerns determines the executive failure of task information processing.

1.4.2 – The decoupling hypothesis

The decoupling hypothesis (Smallwood and Schooler, 2006) suggests that, during MW episodes, executive resources are directed away from the primary task in order to allow the flow of thoughts. According to this hypothesis, executive control does not control the generation of self-generated thoughts, but, as soon as they become the focus of attention, is relevant for the continuity of the train of thoughts (Smallwood, Brown, Baird & Schooler, 2012). Some domain-general processes can be considered as mental processes that are common both to internally and externally guided trains of thoughts (Smallwood & Schooler, 2006), thus there is a competition for the same resources. Given that, when an individual engages herself/himself in thoughts that are not related to the task at hand, resources involved in processing inner thoughts will not be available for elaborating external stimuli because of the limited availability of cognitive resources (Smallwood, 2013). Considering this, MW might be more likely to occur when the task at hand is automatic and does not rely on executive control than when the task is more demanding. In line with the decoupling hypothesis, Christoff, Gordon, Smallwood, Smith and Schooler (2009) observed that not only the default network[1] (Buckner, Andrews-Hanna & Schacter, 2008; Raichle et al., 2001; Raichle & Snyder, 2007), but also the executive network[2] are active during MW states. Additional evidence in support to the decoupling hypothesis comes from a study by Levinson, Smallwood and Davidson (2012). The authors administered a low demanding task and assessed the participants' working memory skills (WM). As a result, individuals with higher levels of WM referred higher scores of thoughts that were unrelated to the task at hand than persons with lower levels of WM. Moreover, in another study, cognitive control played a major role in adjusting the frequency of MW depending on the difficulty of the task at hand (Rummel & Boywitt, 2014) as individuals with higher levels of WM were more able to shift, when necessary, from off-task thoughts to on-task. Interestingly, Kam and Handy (2014) observed that executive resources are not globally recruited during MW episodes. Rather, MW engages inhibition and updating of working memory, rather than shifting.

[1] The Default Network is a large-scale neural network which includes several brain regions (medial prefrontal, posterior cingulated and retrosplenial cortices, medial and lateral temporal lobes, and posterior inferior parietal lobes. This network shows high activity during resting states, whereas during demanding tasks its activity is generally reduced (Greicius, Krasnow, Reiss & Menon, 2003). Recent findings highlight an association between MW and increased activity in the Default Network.

[2] The Executive system mainly includes the dorsal anterior cingulated and the dorsolateral prefrontal cortex that are active when individuals are engaged in external sensory processing.

1.4.3 – The executive failure hypothesis

According to the executive failure hypothesis (McVay & Kane, 2009, 2010, 2012), sustained attention on a task is maintained by processes of executive control that reduce to the minimum potential sources of distraction. As both external stimuli and internal thoughts are considered forms of distraction, the system for attentional control must reduce these distractions. If this system fails to do so, the executive failure determines the flourishing of MW episodes. According to this hypothesis, MW episodes are the consequence of an executive failure, and, differently from the decoupling hypothesis, the continuity of thoughts does not rely on domain-general processes; rather, they are maintained in a resource free-manner (McVay & Kane, 2010; Smallwood, 2013). Several investigations have found a negative association between rate of MW episodes and levels of WM during demanding tasks in everyday life (Kane et al., 2007; Kane & McVay, 2012), and during laboratory assessments involving complex span tasks (Mrazek, Smallwood, Franklin et al., 2012), sustained attention (McVay & Kane, 2009) or reading (McVay & Kane, 2012; Unsworth & McMillan, 2013). As a result, it seems plausible that executive control contributes in monitoring and reducing interferences.

1.4.4 – The context regulation hypothesis

Interestingly, neither the executive failure hypothesis nor the decoupling hypothesis can explain all the available findings. For example, the decoupling hypothesis does not provide an explanation about why people with good cognitive control (i.e., high WM) report lower percentages of MW episodes during demanding tasks (e.g., McVay & Kane, 2009; Kane et al., 2007). On the other hand, the executive failure hypothesis cannot explain the positive correlation found between WM and MW episodes during low demanding tasks (Levinson et al., 2012; Rummel & Boywitt, 2014). According to an alternative account, i.e., the context regulation hypothesis (Smallwood &Andrews-Hanna, 2013), it has been proposed that task-unrelated thoughts might be flexibly modulated by cognitive control depending on task demands. This adaptation allows to minimize the costs and take advantage from self-generated thoughts while performing another task. Thus, executive control can inhibit unrelated thoughts when the context is considered as demanding, but let the mind wander when the resources needed to perform the task at hand are low. For this reason, the context regulation hypothesis emphasizes the role of task context in understanding better costs and benefits (for example, creativity, mental break, future planning) of MW.

1.4.5 – The meta-awareness hypothesis

It has been suggested that the meta-representation of awareness is a factor that plays a main role in MW occurrences by detecting whenever our mind is occupied by other processes than those required by the task at hand significantly affects MW Schooler (2002). Indeed, the mind is not always aware of the engagement in MW, but it is only intermittently aware of it (Schooler et al., 2011) determining a temporal dissociation between experience and meta-consciousness. Thus, MW episodes might continue for a while before the individual becomes aware of them (Schooler, 2002; Smallwood & Schooler, 2006; Schooler, Reichle & Halpern, 2004). The ability to re-represent contents of awareness allows people to identify thoughts at hand knowing whether they deviate from the aims of what they are currently doing (Smallwood, 2013). Considering this, a breakdown in meta-awareness allows a decoupling of attention from stimuli to thoughts unrelated to the task. Moreover, it has been highlighted that mindfulness training enhances the levels of consciousness of the present (Smallwood & Schooler,

2015) and might minimize the negative effects of MW (Mrazek, Smallwood & Schooler, 2012; Mrazek, Franklin, Phillips, Baird & Schooler, 2013). For example, Mrazek Smallwood & Schooler (2012) proposed an eight minutes mindful breathing task observing that it induced a decrease in the production of errors during a vigilance task. Furthermore, Mrazek and colleagues (2013) showed that a two-weeks mindfulness training can reduce the percentage of MW episodes during a reading task, and during a working memory task, determining a task improvement.

1.5 – The costs of Mind Wandering

Several investigations have shown that MW has a cost in terms of speeding up of reaction times (RTs) during tasks of sustained attention (Cheyne, Solman, Carriere & Smilek, 2009; Hu, He & Xu, 2012), lower levels of text comprehension (Unsworth & McMillan, 2013), difficulties in performing daily activities (McVay, Kane & Kwapil, 2009), and narrowed focus of attention during driving simulations (He, Becic, Lee & McCarley, 2011). These lines of evidence are detailed in the following sub-paragraphs.

1.5.1 – Performance on tasks of sustained attention

The sustained attention to response task (SART, Robertson et al., 1997) is a go/no-go task that has been frequently used to assess MW (Cheyne et al., 2009; Christoff et al., 2009; Hu et al., 2012; McVay & Kane, 2009; Smallwood, Beach, Schooler & Handy, 2008; Seli, Risko & Smilek, 2016b; Smallwood, Riby Heim & Davies, 2006) and is characterized by ecological validity (Smilek, Carriere & Cheyne, 2010). This task is commonly used because of its known sensitivity to MW episodes. Participants are required to respond as fast and accurate as possible to non-target stimuli (which occur almost always during the task) and refrain from responding when shown a target stimulus which occurs with extremely low frequency. Such stimuli can be in different modalities. The high frequency of non-target presentation can lead to mindless responses. For this reason, the SART is frequently used to investigate MW and its effects on task performance. Four indexes are usually taken into consideration, namely commission errors (i.e., no-go errors), variability of reaction times, omissions, and anticipations. The RTs recorded during the SART are sensitive to changes in the levels of attention during the task: shorter RTs tend to precede errors, whereas longer ones are usually observed immediately after an error probably because of a return of the focus of attention on the task at hand. Specifically, a difference between RTs that precede and those that follow an error due to the inability to sustain attention is frequently observed, and this difference usually consists of a pre-error speeding of RTs followed by a post-error slowing of RTs (Jackson & Balota, 2012; Smallwood et al., 2004). This alternation between speeding and slowing down led to a variability of RTs (i.e., reaction time coefficient of variability, RTCV) that was shown to be associated with MW (Hu et al., 2012; McVay & Kane, 2009; Cheyne et al., 2009). Anticipations and omissions reflect RTs to non-target stimuli that are too fast (< 100 ms) and missing responses to non-target stimuli, respectively. These measures are frequently used as indirect markers of MW episodes, considering errors as a deeper form of attentional disengagement, whereas the variability of RTs mirrors a less disturbing form of disengagement resulting from an automatic processing rather than an attentive one (Cheyne et al., 2009). During a SART the stimuli are frequently presented with slow pace with inter-stimulus intervals of approximately 2 seconds, in order to make the task boring and undemanding from a perceptual point of view (Christoff et al., 2009; Hu et al., 2012; Smallwood et al., 2004). In addition, frequency of target presentation is also relevant, as low target presentation does not provide external (exogenous) support to maintain attention on the task, whereas high probability of target presentation may act in the opposite manner (Manly, Robertson, Galloway & Hawkins, 1999; Smallwood et al., 2004). Thus, low target probability may encourage the occurrence of MW states during a sustained attention task. Episodes of MW tend to increase over the task (McVay & Kane, 2009; Smallwood et al., 2004). Additionally, a study by Hu and colleagues (2012) examined the relation between MW episodes reported during a sustained attention task and components of attention as measured by administering the Attention Network Test (ANT, Fan, McCandliss, Sommer, Raz & Posner, 2002). The authors found a negative correlation between MW frequency and orienting attention: those participants whose mind tended to wander the most benefited less from spatial cues. Moreover, McVay and Kane (2009) showed that MW frequency partially mediated the relation between WM and performance at SART showing evidence of the role of executive control of thoughts during task performance in order to remain on task.

Recently, another task of sustained attention has been employed to study MW. It is the metronome response task (MRT; Seli, Cheyne & Smilek, 2013) that consists of a continuous rhythmic presentation of tones. Participants are asked to respond synchronously with tones presentation by pressing a key, and at irregular intervals are presented with a thought probe (Seli, Cheyne & Smilek, 2013; Seli, Risko & Smilek, 2016a; Seli, Cheyne, Xu, Purdon & Smilek, 2015; Seli, Jonker, Cheyne, Cortes & Smilek, 2015). The MRT requires continuous attention to the task in order to synchronize button press with the presentation of upcoming tones. Thus, failures in sustaining attention may determine a variability in RTs leading to higher variability when off-task than on-task (Seli, Cheyne & Smilek, 2013). This suggests that behavioural variability might be representative of MW.

Motivation to perform well in the task was demonstrated to be an important factor to remain focused on task; indeed, low levels of motivation led to more frequent MW episodes that were associated with a decrement in performance (Seli, Cheyne et al., 2015).

1.5.2 – Encoding

A number of studies investigated how MW affects encoding of perceptual information and the following retrieval of information (Smallwood, Obonsawin & Heim, 2003; Smallwood, Baracaia et al., 2003; Smallwood, O'Connor & Heim, 2005; Smallwood, Riby et al., 2006). Retrieval usually occurs via two routes: recollection vs. familiarity (Jacoby, 1998; Jennings & Jacoby 1993) or explicit vs. implicit (Szymanski & MacLleod, 1996). Recollection and explicit retrieval are considered forms of conscious retrieval of information. On the other hand, familiarity and implicit retrieval may occur as a result of a stimulus that has been processed unconsciously. Thus, considering MW as a shifting of attention, it might determine a retrieval driven by familiarity instead of recollection as a result of the superficial stimuli representation.

To assess the relationship between encoding and MW, participants are usually shown with a list of words, or a semantic SART and then, during the recall session, they are asked to recall as many words as possible from the encoding condition. Categorical processing was highlighted to allow an easier maintenance of focus of attention on task than non-categorical processing such as random stimuli presentation (Smallwood, Baracaia et al., 2003; Smallwood, Obonsawin & Heim, 2003). Thus, task unrelated thoughts might be influenced by how easily the incoming information can be integrated into the "current state of knowledge" (Smallwood, Obonsawin & Heim 2003). Additionally, MW during the list of words encoding phase can be associated with an increase of false alarms during the retrieval phase (Smallwood, Baracaia et al., 2003). Participants were presented with a list of words which was followed by a retrieval session, that could consist of word-fragment completion and word recognition, showing that MW could trigger more false alarms during the word-fragment completion (Smallwood; Baracaia et al., 2003). Semantic SART is a task that was also used to assess the relation between encoding, information retrieval and attentional lapses (Smallwood et al., 2006). This modified version of the SART consists of a presentation of a sequence of verbal stimuli to which participants are asked to respond, whereas on target stimuli presentation they must refrain from responding. Results showed that items that follow an error were more likely to be retrieved on the basis of recollection compared to items that precede the error, whilst retrieval on the basis of familiarity did not change depending on considering the period before or after an error. As last, target probability is an issue of main relevance also during encoding tasks. With few target stimuli participants need to control their attention because the task did not provide exogenous support. Indeed, during a semantic SART with low target probability participants took advantage from retrieval based on recollection when they reported they had been on task, whereas no significant difference between retrieval based on familiarity or recollection was shown when off-task. On the other hand, SART with high frequency of target provided external support to attention determining no specific association between MW and performance level (Smallwood, McSpadden & Schooler, 2007).

Encoding of information is essential during reading or oral comprehension, these results concerning MW effects on encoding of information suggest that MW could lead to cascade consequences on mental model building. In the next paragraph MW effects on reading are described in depth.

1.5.3 – Reading

Reading needs deep engagement with the text at hand in order to identify and retain relevant information for the generation of a narrative model (Smallwood, Fishman & Schooler, 2007). During attentive reading, perceptual information is converted into a super-ordinate representation of the narrative through different stages of representation (Smallwood, 2011). Three levels of representation are described as being necessary for reading, namely lexical, propositional, and situational levels. The lexical meanings are generated from perceptual information, then words are organized into propositions or clauses which are then arranged into a super-ordinate representation of the narrative providing a context that might help the interpretation by linking general knowledge to narrative events. Reading and comprehension are important skills in daily life, such as in educational and job settings and leisure time. It often happens to read a text and suddenly find our mind not be present to the text anymore needing to go back to re-read the text. When the mind wanders the superficial engagement with the text at hand hinders the creation of the corresponding propositional and situational model because the reader would need to actively generate inferences and retrieve knowledge that goes beyond what is described in the text (Smallwood, 2011). A typical way to investigate the effect of MW on reading and comprehension skills is to administer a text that participants must read covertly. At irregular interval they are interrupted by a thought probe in order to assess whether they were still focused on the task. Generally, MW episodes during reading tasks are associated with poorer levels of text comprehension (Schooler et al., 2004; Smallwood, McSpadden & Schooler, 2008). Meta-awareness of MW was demonstrated to be very important. Indeed, a higher frequency of MW, characterized by lacking of awareness, during critical episodes of the text impeded the generation of a correct situation model (Smallwood, McSpadden & Schooler, 2008).

Interestingly, a difference in the frequency of MW was also found between covert and overt reading conditions: higher frequency of MW was reported during overt reading (Franklin, Mooneyham, Baird & Schooler, 2014). Moreover, differences in vocal output were observed between attention and mindless reading. Specifically, the volume was higher and characterized by less variability during MW than during attentive reading (Franklin et al., 2014).

Working memory is a well-known factor that plays a relevant role during reading tasks. It allows readers to keep actively text information for the subsequent integration with new information provided by the text (Daneman & Carpenter, 1980; Daneman & Hannon, 2001). Thus, low WM may lead to reduced ability in integrating information from the text with the reader's knowledge about the topic into a mental model. Readers who score lower in working memory tasks are more likely to report more MW episodes while reading a text (Unsworth & McMillan 2013). McVay and Kane (2012) explored whether MW plays a mediating role in the association between WM and text comprehension. They observed that MW partially mediated the relation between WM and text comprehension. However, WM was not the only factor involved in reading comprehension. Additional factors such as the level of interest and motivation exerted by the text had a relevant impact as well. For example, Unsworth and McMillan (2013) examined how WM, level of interest, degree of knowledge about the topic of the reading task, and level of motivation to perform well on the task affect MW frequency. They found that not only WM but also the level of interest and motivation played a major role in determining the occurrence of MW. Specifically, a structural equation model showed that low levels of interest lead to poor motivation to perform well on task that turns into high frequency MW episodes. Interestingly, WM was independent from the level of interest and motivation. Thus, frequency of MW might be influenced both by domain-general (i.e., working memory) and domain-specific (i.e., levels of interest and motivation) factors. Furthermore, MW was more likely during difficult text than easy ones, and when the reader's attention is decoupled from the text at hand and the text at issue is complex, MW affects more the level of comprehension (Feng, D'Mello & Graesser, 2013).

As previously mentioned, measurement of MW was frequently associated with physiological and behavioural indexes (Franklin, Broadway, Mrazek, Smallwood & Schooler, 2013; Reichle, Reineberg & Schooler, 2010; Schad, Nuthmann, & Engbert, 2012) that can be considered as objective measures of MW. Physiological indexes, such as eye movements or pupil dilatation, highlighted the effects of mindless reading on the lexical level. Mindless reading was characterized by longer fixation times than that observed during focused reading, and by fewer sensitivity to lexical aspects such as length and frequency (Reichle et al., 2010). This suggests a decoupling of attention from the text at hand. Moreover, eye movement during mindless reading was described as erratic (Reichle et al., 2010), and less complex (Uzzaman & Joordens, 2011). In addition to eye movement, there is also pupillometric evidence as correlate of MW. Indeed Franklin, Broadway and colleagues (2013) observed that pupil dilation was higher during MW episodes than when on task. Concerning behavioural indexes, mindless reading during a word-by-word paradigm determined variation in RTs depending on the mental state. Starting from the reaction time effect, Franklin, Smallwood and Schooler (2011) formulated an algorithm to be used during a word-by-word reading paradigm in order to identify online, without any thought sampling, when participants are mindless reading. When paying attention, RTs were increased for long, barely familiar and multisyllabic words, whereas these effects were diminished during mindless reading (Franklin et al., 2011).

1.5.4 – Everyday life attention

A number of studies considered the impact of MW in everyday life (Kane et al., 2007; Killingsworth & Gilbert, 2010; McVay, Kane & Kwapil, 2009; Ottaviani & Couyoumdjian, 2013; Song & Wang, 2012; Unsworth, McMillan, Brewer & Spiller, 2012). Killingsworth and Gilbert (2010) contacted 2,250 adults using an iPhone application and found that MW is a rather frequent phenomenon that occurs when we are performing our common activities, regardless of what we are doing. A similar study, using an experience sampling method, attempted to examine MW in daily life in Chinese individuals (Song & Wang, 2012). The reported thoughts were mainly future-oriented, related to personal life, and elicited by both internal and external cues. Their results also showed that frequency of MW might be influenced by factors such as attention orientation, mood, and devotion to the task. Thus, the pervasiveness of MW was observed even in everyday life with a very high frequency (Kane et al., 2007; Killingsworth & Gilbert, 2010; McVay et al., 2009). A connection point between laboratory and everyday life is provided by the study performed by McVay and colleagues (2009) who highlighted coherent results between these two contexts: those who reported higher frequency of MW during laboratory task reported also higher frequency of MW in everyday life. Similarly, considering the distinction between spontaneous and deliberate MW (Seli, Risko & Smilek, 2016b) the tendency to report intentional MW during a task performed in laboratory mirrored the same tendency even in everyday life (Seli, Risko & Smilek, 2016a).

Moreover, differences in aspects related to attentional control, as measured by WM, were assessed to explore whether there is a relation with MW in everyday life. For example, Kane et al. (2007) showed that WM mediates the relation between frequency of MW and cognitive demand of the activity at hand. Specifically, when the activity at hand needed a high level of concentration, high-WM participants reported to be on task more frequently than low-WM participants, whereas when the level of concentration required by the activity at hand was low they were more likely to let their mind wander. On the other hand, low-WM participants tended to wander more during challenging and effortful activities, whereas high-WM were stably on task. Additionally, a positive correlation was observed between the frequency of MW during a laboratory task and daily activities performed 1 year later (Ottaviani & Couyoumdjian, 2013). Thus, the tendency to let the mind wander seems to be a stable cognitive characteristic and an individual disposition (Kane et al., 2007; McVay et al., 2009; Ottaviani & Couyoumdjian, 2013). In a recent study, a group of undergraduate students were given a diary in order to indicate their attention failures during daily activities over 1 week (Unsworth et al., 2012). The students reported that the most frequent failures of attention occurred when they were distracted while studying, and let their minds wander in class. These results provide information about a further context where MW might occur, namely educational context. Smallwood, Fishman and Schooler (2007) described the influence of an absent mind in educational settings as an under-recognized problem. In recent years, several studies have focused on the relation between MW and education (Lindquist & McLean, 2011; Risko, Anderson, Sarwal, Engelhardt & Kingstone, 2012; Szpunar, Khan & Schacter, 2013; for a review see Szpunar, Moulton & Schacter, 2013), and on the difference between intentional or unintentional MW during lectures (Seli, Wammes, Risko & Smilek, 2016; Wammes, Boucher, Seli, Cheyne & Smilek, 2016; Wammes, Seli, Cheyne, Boucher & Smilek, 2016). MW during lectures can be assessed using an auditory probe sound in the class during the lecture. When they hear this sound, the students are required to report whether they were wandering or not. In line with other studies, the occurrence of states of MW depends on time on task even in educational settings as MW frequency increased with time on lecture (Risko et al., 2012; Lindquist & McLean, 2011). It was shown that as frequency of MW increases participants are less able to remember what they have just heard, especially when questions were about aspects presented in the second half of the lecture (Risko et al., 2012), the quality of performance in course examination is poorer, and note taking and level of interest in the subject are lower (Lindquist & McLean, 2011). Interestingly, in the majority of the cases students reported that they let their mind wander intentionally rather than unintentionally (Wammes, Boucher et al., 2016). Additionally, costs of MW depend on the intentionality; indeed intentional MW was associated to short-term costs, such as lower retention of material presented during lectures, whereas unintentional episodes were linked to final exam scores (Wammes, Seli et al., 2016). In conclusion, these findings suggest that some strategies might lower the frequency of MW during lectures. For example, Szpunar, Khan and Schacter (2013) suggested that interpolating tests during lectures might improve later retention of lecture material discouraging unrelated thoughts.

1.5.5 – Driving

A recent line of research considers the relationship between MW and driving behaviour. To date, only few studies investigated such relation. Some used driving simulation tasks (He et al., 2011; Yanko & Spalek, 2014), others used questionnaires (Berthié et al., 2015; Burdett, Charlton & Starkey, 2016; Galéra et al., 2012). Galéra and colleagues (2012) conducted an epidemiological study that showed that MW just before a car crash may determine a higher probability to be responsible for the crash. Furthermore, driving simulations might help to explore whether and how MW directly affects driving performance. These have shown a narrowing of drivers' visual attention

(He et al., 2011), a slowing down of RTs to sudden events and a less safe distance from the ahead car (Yanko & Spalek, 2014). Other studies used questionnaires. For example, Berthié and colleagues (2015) observed contextual aspects played a main role as familiar routes and monotonous motorways can encourage the occurrence of episodes of MW. Recently, Burdett and colleagues (2016) confirmed that familiar roads can favour MW, and reported that tired and younger drivers may let their mind go away from driving environment more frequently. Results of these studies will be described in grater details in Chapters 4 and 5.

In conclusion, the literature about MW and driving provides an initial knowledge about MW during every day driving and about the direct consequences on driving performance. Considering the well-known costs of MW on task performance, further studies should be conducted in order to learn more about that in order to raise awareness among drivers about this risk behind the wheel.

1.6 – The benefits of Mind Wandering

Despite the costs of MW, a number of studies have suggested a functional role of MW, such as future thinking and creative thinking (Baird et al., 2011; Stawarczyk et al., 2011; Baird et al., 2012). As previously mentioned, several studies provide information about the temporal orientation of MW showing that it is primarily future-oriented (Baird et al., 2011; Smallwood, Nind & O'Connor, 2009; Stawarczyk et al., 2011). As MW is thought to arise due to current concerns (Klinger, 1999), a functional role of MW might be represented by future planning and anticipation of important own goals (Mooneyham & Schooler, 2013; Smallwood & Schooler, 2015). Therefore, even if it may determine performance deficits, the positive side of the coin is that MW provides a personal remuneration derived from autobiographical planning.

MW has also been associated to creative thoughts, namely the ability to generate new thoughts (Mooneyham & Schooler, 2013; Smallwood & Schooler, 2015). Using an incubation paradigm, Baird and colleagues (2012) observed that a break while engaged in an undemanding task (that might encourage MW) increases performance on the Unusual Uses Task (UUT), a measure of divergent thinking (Guilford, 1967). The UUT consists of the presentation of common objects after which participants are asked to produce as many uncommon uses as possible for each of them and this is considered as a measure of creative thinking.

Other possible functional roles of MW may be the relief from boredom and attentional cycling (Mooneyham and Schooler, 2013). About these possibilities, our mind is able to disengage from the here and now engaging itself in a stream of thoughts unconnected with the task at hand, and then focusing again on external stimuli allows a switching between multiple goals at the same time. Given that, MW may even be thought as a mental break relieving from the boredom of the current activity.

1.7 – Summary points of the literature review

In conclusion, these are the most salient points of the literature review performed in this Chapter:

- ❖ MW refers to self-generated thoughts, but self-generation does not necessarily explain the non-relatedness to the task at hand; indeed it is important to distinguish between self-generated thoughts that are related, such as considerations about task performance, and unrelated to the task at hand, such as planning something for the future or think back to something about the past. There is evidence supporting the importance of distinguishing these aspects as well as emphasizing the awareness of MW.

- MW is investigated by using experience sampling techniques that consist of collecting current individuals' thoughts. These techniques include: (1) Probe-caught method: at irregular intervals a thought-probe is presented to participants in order to assess the contents of their minds; (2) Self-caught method: participants report by themselves every time they realize that their mind is off-task; (3) Retrospective method: the task at hand is performed without being stopped, and information about mental experience is provided at the end; however this measurement relies to a great extent on memory.
- MW seems to be temporally characterized with a future-oriented bias.
- Meta-awareness is defined as the explicit awareness about current contents of thoughts. A temporal dissociation between experience and meta-consciousness was observed when we lack of awareness of our contents of mind. Given that, probe-caught sampling might allow to catch not only episodes that are characterized by awareness, but also those cases lacking of awareness.
- MW seems to be a cognitive stable characteristic; indeed it has been observed coherent results across laboratory tasks and everyday activities.
- Several hypotheses have been formulated to account for the cognitive underpinnings of MW: the current concerns hypothesis, the meta-awareness hypothesis, the executive failure hypothesis, and the decoupling hypothesis. Briefly, the current concerns hypothesis argues that each individual has goals, concerns, plans that go beyond the here and now that might trigger task-unrelated thoughts that are considered as more salient than external events. As second, it was hypothesized that the breakdown in meta-awareness may play an important role in favouring MW allowing a decoupling of attention from perception. As third, the executive failures hypothesis claims an inability to inhibit irrelevant thoughts when performing a

primary task. As fourth, the decoupling hypothesis suggests a withdrawal of executive resources from primary task to inner thoughts. These hypotheses seem to explain different aspects of MW, namely the why, in case of current concerns hypothesis, of meta-awareness hypothesis, and of executive failures hypothesis, and the how, in case of decoupling hypothesis, of MW occurrence. MW has been studied using tasks that posit different demands on attention. On the one hand, individuals with high levels of executive control are more likely to limit their task-unrelated thoughts during demanding tasks, but tend to refer a higher occurrence of task-unrelated thoughts during undemanding tasks. The context regulation hypothesis claims that executive resources can suppress or enhance MW depending on external task demands.

- ❖ The current research has unveiled the costs and benefits of MW. It affects negatively the performance on tasks assessing attention, encoding, reading, and driving skills. However, it may increase autobiographical planning, enhance creativity, and act as a mental break relieving from boredom during monotonous tasks.

1.8 – Outline of the thesis

From the studies described in this Chapter it is evident that MW is a very common experience in daily activities and that the tendency to let our mind wander seems to be a stable cognitive characteristic across laboratory and everyday activities affecting what people are doing. Consequently, the current thesis describes series of experiments designed to explore the cognitive underpinnings of MW and its occurrence across different domains of daily activities such as narrative discourse production and driving.

Experiment 1 of Study 1, presented in Chapter 2, underlines the relevance of not considering MW as an unique construct, rather the necessity of distinguishing depending on awareness, lacking of awareness, blanking, or thoughts related to performance quality. The majority of the studies defined the mental state experienced before the probe presentation as on-task or off-task. However, the necessity of differentiation between intentional and unintentional MW was emphasized (Seli, Risko & Smilek, 2016b), suggesting that the intentionality in engaging in MW seemed to be characterized by consciousness of intention of the drifting of attention from the task at hand, whereas unintentional MW episodes were described as lacking of conscious initiation (Seli, Risko, Smilek & Schacter, 2016). Several theories were suggested to explain the phenomenon of MW, such as the decoupling hypothesis (Smallwood & Schooler, 2006; for details see §§ 1.4.2), and the executive failure hypothesis (McVay & Kane, 2009, 2010, 2012; for details see §§ 1.4.3); these theories tried to explain the role of executive resources during MW. Accordingly to the model suggested by Miyake, Friedman, Emerson, Witzki and Howerter (2000), three executive components might be identified: inhibition, updating of working memory, and set-shifting. Specifically, inhibition involves the control of attention, behaviour, and thoughts in order to override a dominant or automatic response; updating of working memory refers to the ability to retain information in mind and actively manipulate it; and set-shifting pertains to the ability of shifting from one task to the other. Considering this, the preliminary study presented in Chapter 2 aimed at determining the cognitive characteristics of MW mental states, as defined as aware of MW, unaware of MW, blank mind, and thoughts related to performance quality, and at assessing whether they might be explained by specific cognitive factors.

Experiment 2 of Study 1, presented in Chapter 3, considers the relation between narrative discourse production and MW. Narrative production tasks might be considered as goal-directed thinking or an action similar to complex structured event knowledge

(Wood, Knutson & Grafman, 2005; Ylvisaker, Szekeres & Feeney, 2008). Moreover, narratives are considered to be based on the knowledge about schemas and regularities in the story structure known as story grammar knowledge (Stein & Glenn, 1979) that is known to be associated to executive functions (for further details see Chapter 3). In addition, according to the Structure Building Framework suggested by Gernsbacher (1990), message production requires three processes: laying a foundation, mapping, and shifting. A prelinguistic conceptual phase is determinant when the speaker, through a process of foundation laying, generates a structure or mental depiction of the story that will act as foundation for its development. As information flows, a constant monitoring of the generated structures is needed, and in case of inconsistent structure a shifting is needed in order to generate a new one. Over time, several structures are generated and subsequent piece of information needs to be mapped into the appropriate structure. Even in this case, cognitive skills are crucial for these processes. In the study presented in Chapter 3 a multi-level approach to discourse analysis (Marini, Andreetta, del Tin & Carlomagno, 2011) was used in order to assess how effective and informative, from a communicative point of view, participants' discourse productions were. According to this, we hypothesized that this ability to convey correct and relevant information might be considered as the ability to stay on task keeping in mind the aim of the task at hand without derailing from it. The aims were to investigate whether the ability to stay on task during an attention task, during daily life (as measured by the Cognitive Failures Questionnaire [CFQ; Broadbent, Cooper, Fitzgerald & Parkes, 1982]), and the ability to communicate effectively, conveying relevant information, are related, and whether it was possible to identify an index of derailment from the purpose of what it is being done which could be explained by a role played by Executive Functioning.

Study 2, presented in Chapters 4, and Study 3, presented in Chapter 5, are about MW and driving. Despite the large number of studies about MW and its effects on the task at hand showing the negative effects of the decoupling of attention from what we are doing, little is known about MW behind the wheel. Indeed, only few studies directly investigated the topic of MW and driving (He et al., 2011; Yanko & Spalek, 2014), and other studies deepened the knowledge by using a questionnaire methodology (Berthié et al., 2015; Burdett et al., 2016). Considering the possible relevance of this topic, even in safety road perspective, a second aim of this thesis was to explore the relation between MW and driving performance. To do this, a driving simulated study was performed, and a questionnaire about inattentiveness behind the wheel was developed. Specifically, Study 2, presented in Chapter 4, explored MW effects on basic driving skills. Although previous studies (He et al., 2011; Yanko & Spalek, 2014) used a car-following task, in this study a simple lane-keeping task was used in order to assess MW effects on basic driving behaviours as measured by speed, angle of steering wheel, and lane position. Indeed, in a car-following task more cognitive resources are involved due to the presence of the leading car that can be considered as an additional variable, as compared to the relatively automatic driving skills required during a lane-keeping task. Moreover, considering that the study of MW effects on driving performance is still in its infancy, and that the previous two studies used the probe-caught method in one case (Yanko & Spalek, 2014), and the self-caught method in the other (He et al., 2011), it was of main interest to assess the difference between these two methodologies in the context of driving performance. Study 3, presented in Chapter 5, presents a new questionnaire about inattentiveness behind the wheel in order to explore MW during everyday driving. As previously mentioned, the issue of MW behind the wheel has been studied even by using questionnaire in order to collect information about this topic. However, only two studies used an off-line method (Berthié et al., 2015; Burdett et al., 2016). Considering the limited knowledge about MW behind the wheel during everyday driving, the development of a new questionnaire about the inattentiveness during everyday driving was thought to be of particular interest in order to deepen the knowledge about that.

Chapter 2

The roots of Mind Wandering. Assessing the role of executive functioning

2.1 – Introduction

It is an everyday common experience to suddenly realize that our mind drifted away while we were doing something else. As discussed in Chapter 1, MW is commonly assessed using a thought sampling, namely probe-caught and self-caught (Smallwood & Schooler, 2006). These two methodologies differ as in the former participants are asked to report mental states experienced just before probe presentation, whereas the latter implies that participants self-report MW episodes each time they become aware of it. Probe-caught sampling allows to capture not only those episodes that are characterized by awareness, but also those instances that lack of awareness. Schooler (2002) suggested that sometimes we lack of awareness of our mind contents determining a temporal dissociation between experience and meta-consciousness. Additionally, Seli, Risko and Smilek (2016b) emphasized the difference between intentional and unintentional MW. In their review Seli, Risko, Smilek and Schacter (2016) suggested that intentional MW seemed to be characterized by consciousness of intention of the drifting of attention from the task at hand, whereas unintentional MW episodes were described as lacking of conscious initiation. Other studies have emphasized that sometimes attention may neither be directed to the task, nor to unrelated thoughts, but simply disappear; this mental state is known as mind-blanking (Jackson & Balota, 2012; Ward & Wegner, 2013). Ward and Wegner (2013) described mind-blanking as a mental state characterized by an extreme decoupling of attention, and by an attention failure to bring any stimuli into awareness regardless of its nature. As last to be mentioned, another differentiation should concern those thoughts regarding performance due to their ambiguous nature since they are neither about task nor about irrelevant aspects (Hu, He & Xu, 2012; McVay & Kane, 2009). As mentioned in Chapter 1, these thoughts are labelled as task related interference (TRI).

Most of the investigations conducted so far have considered MW as a unique construct. Nonetheless, increasing evidence suggests the need to consider the different kinds of MW that characterize our mental life (Seli, Risko and Smilek, 2016b). As mentioned in Chapter 1, in order to account for the relationship between executive functions and MW, two major hypotheses have been proposed so far: the decoupling hypothesis (Smallwood & Schooler, 2006) and the executive failure hypothesis (McVay & Kane, 2009). The former suggests a withdrawal of executive resources from the primary task to inner thoughts, whereas the latter claims a main role played by executive resources due to incapacity to inhibit thoughts. Apparently, working memory (WM) plays a different role depending on how demanding the task is, namely individuals with high levels of WM referred more frequent MW states during low demanding tasks (Levinson, Smallwood & Davidson, 2012). Interestingly, on the contrary, they were more able to stay on task in case of demanding situations (McVay & Kane, 2009; Kane et al., 2007). Accordingly to the executive resources model suggested by Miyake, Friedman, Emerson, Witzki and Howerter (2000), three executive components might be identified, including inhibition, updating of working memory, and set-shifting. About this model, inhibition refers to the control of behaviours or thoughts overriding dominant responses, updating of working memory involves monitoring and active manipulation of contents, and set-shifting pertains to a flexibility in shifting from one task to the other. About that, a non-unitary recruitment of executive resources has been observed when the mind wanders (Kam & Handy, 2014). MW was shown to affect performance during inhibition and working memory tasks, but no changes were observed during set-shifting tasks; thus, MW might not recruit executive resources in the same manner (Kam & Handy, 2014). Unfortunately, these studies considered MW as a unique construct and did not control for the levels of awareness of the participants nor for possible states of mind-blanking. Other investigations have focused on MW states in everyday activities (Kane et al., 2007; Killingsworth & Gilbert, 2010). By interrupting participants at random moments, it was observed that the mind tends to wander very frequently during daily life. A study by McVay, Kane and Kwapil (2009) bridged the gap between laboratory studies that assess MW and the few studies about MW during everyday activities showing that the tendency to let the mind wander seems to be a stable cognitive characteristic across different contexts. Another methodology to study MW during daily activities makes use of questionnaires. For example, Burdett, Charlton and Starkey (2016) observed that frequency of MW during everyday driving was correlated with mindful attention in daily life, as measured by the Mindful Attention and Awareness Score (MAAS; Brown & Ryan, 2003), and with the occurrence of cognitive failures, as measured by the Cognitive Failures Questionnaire (CFQ; Broadbent, Cooper, Fitzgerald & Parkes, 1982). Given the high correlation between the CFQ and the MAAS, CFQ was not considered in the regression model in order to avoid multicollinearity effect. This model showed that the MAAS accounted for a significant amount of explained variance of MW frequency during everyday driving. Therefore, the tendency to pay mindful attention or the occurrence of cognitive failures seem to play a role in accounting for differences in MW reports.

Also other factors more closely related to the task at hand, such as the level of interest in the task at hand and its difficulty, have been suggested to play a relevant role in determining the frequency of states of MW. For example, Unsworth and McMillan (2013) observed that MW during a reading task was influenced by the level of interest in the topic of the text. As for the impact of the difficulty of a task, it has been shown that easier tasks may trigger MW episodes as they leave available a significant amount of executive resources (Smallwood & Schooler, 2006; Jackson & Balota, 2012). So, a task that is experienced as more difficult might have determined an allocation of more resources to the task at hand leading to less frequent states of MW.

2.2 – Aims of the study[3]

Under the assumption that MW episodes are not a unitary construct, this study aimed at (1) measuring the frequency of different types of MW during the execution of a SART, (2) investigating the effects of MW on task performance, and (3) exploring the cognitive characteristics of MW episodes as differently defined (i.e., aware of MW, unaware of MW, blank mind, and TRI) (for details see §§ 2.3.2). As the first issue, in this study participants could characterize the mental state experienced just before probe presentation. Considering that MW frequency tends to increase during the task at hand (McVay & Kane, 2009; Smallwood, Obonsawin & Heim, 2003; Smallwood, Riby, Heim & Davies, 2006), we attempted to explore how this tendency varies considering mental state characterization (i.e., aware of MW, unaware of MW, blank mind, and TRI). As the second issue, performance at the SART was calculated as behavioural

[3] The experiment described in this Chapter and in Chapter 3 are part of a wider research involving 65 participants.

indices of MW in order to explore whether and how the characterization of MW affects performance at the SART. As the third issue, in line with the suggestion about the intentionality of MW provided by Seli, Risko, Smilek, and Schacter (2016), the intentional MW refers to a conscious intention to drift attention away from the task at hand, whereas unintentional MW are described as lacking of conscious initiation. According to this suggestion, we hypothesized that cognitive skills might play a different role depending on the mental state experienced.

2.3 – Methods

2.3.1 – Participants

65 healthy young adults (F = 49; M = 16) were recruited for the study (Age: M = 22.18; SD = 3.4; Educational level: M = 13.86; SD = 1.9) (see Table 2.1). None of the participants reported previous episodes of psychiatric disorders, traumatic brain injuries, nor learning disabilities. The study was approved by the Ethical Committee of the University of Trieste. Participants signed the written informed consent before starting the administration of the tasks.

	Range	M	SD
Age	18 – 34	22.18	3.43
Educational level (years)	8 – 21	13.86	1.92

Table 2.1 – Means and standard deviations of demographic information.

2.3.2 – Cognitive tasks

The majority of the studies that explored cognitive aspects of MW examined deeply the role of working memory updating, whereas the components of inhibition and of set-shifting were in part ignored. However, Kam and Handy (2014) suggested a differential recruitment of the executive resources during MW mental states. According to the model suggested by Miyake and colleagues (2000), all participants received a selection of offline and online cognitive tasks that allowed us to assess the component of working memory updating, set-shifting, inhibition. In addition, the cognitive evaluation included also the assessment of attention. Some of these tasks were administered offline, others were created using Psychopy (Peirce, 2007; 2009) and then presented on a laptop in a counter-balanced order.

Working memory updating was assessed by administering the Digit Span Backward and Listening Span Tasks.

- ❖ The Digit Span Backward task was administered in order to investigate the levels of phonological working memory. The participants listened to progressively increasing sequences of numbers and were immediately asked to repeat them in reverse order. Two sequences of numbers were presented for each span. The number of sequences correctly repeated was the index of phonological working memory.
- ❖ The Listening Span Task (De Beni, Borella, Carretti, Marigo & Nava, 2008) needs simultaneous processing and storage of items. It consists of blocks of increasing number of sentences (from 2 to 6). Participants listened to each sentence and were then asked to judge whether it was true or false. At the end of each block they were asked to recall as many last words of each sentence as possible. For instance:

“Butter and jam are eaten with bread” (True)

“The dog is a pet as well as the cat” (True)

At the end of this block of sentences, the participants had to recall "Bread", and "Cat". The total number of words correctly recalled was counted.

Set-shifting was assessed by administering a task of Phonemic Fluency and the Trail Making Test - Parts A and B.

- ❖ The task of Phonemic Fluency requires participants to generate in 1 minute as many words as possible that begin with a specific phoneme. For this task the initial F and S were used. The total number of correct words produced by each participant was then calculated.
- ❖ The Trail Making Test (TMT, Reitan, 1992) requires participants to make a trail with a pencil. It consists of two parts: in Part A they must connect numbers in an increasing order (from 1 to 26); in Part B they must alternate numbers and letters following a sequential order (i.e., 1-A-2-B… and so forth). The total time needed to complete the task was recorded for each part and a composite score was calculated subtracting time to complete Part A from time of Part B (B-A). This score is commonly considered as an index of executive control since visuo-perceptual and working memory components involved in it are removed (Sánchez-Cubillo et al., 2009). A larger difference between time needed to complete the two parts of the test reflects lower set shifting ability.

Inhibition was assessed by administering the Stroop test.

- ❖ In the paper version of the Stroop test by Caffarra, Vezzadini, Dieci, Zonato and Venneri (2002) participants were asked to perform the task in three conditions: in the first participants were asked to read a set of colour names (reading condition); in the second they were required to name coloured circles (naming condition); in the third they had to name the colour in which the words were printed (incongruent condition). An Index of Time Interference was then calculated by subtracting the mean time needed to complete the first and second conditions from the time to complete the third one:

Index of Time Interference = Time Incongruent Condition – ((Time Reading Condition + Time Naming Condition) / 2)

Finally, **attention** was assessed by administering the Attention Network Test and the Sustained Attention to Response Task.

- The Attention Network Test (ANT; Fan, McCandliss, Sommer, Raz & Posner, 2002) assesses the efficiency of three attentional networks[4] that are known to carry out functions of alerting, orienting, and conflict resolution. It combines the flanker task by Eriksen & Eriksen (1974), and the cued reaction time (RT) task by Posner (1980). A central arrow, the target, can point to the right or to the left and be flanked by other arrows that are directed to the same direction (congruent flankers) or to the opposite direction (incongruent flankers), or simply by little lines (neutral flankers) (see Figure 2.1). Furthermore, four different cue types were presented before the onset of the trial: no cue, central cue, double cue, spatial cue (see Figure 2.2). Specifically, the central cue consisted of an asterisk that replaced the fixation point, the double cue was formed by two asterisks appearing at both possible locations (above or below the fixation point), whereas the spatial cue was the only type of cue that provided information about target location as the asterisk appeared where the target would occur. Whole different cues were randomly presented across flanker types. Participants were seating at about 60 centimetres from the laptop. Considering this

[4] Three networks were identified as carrying out alerting, orienting and executive control functions. Firstly, **alerting** is described as the ability to achieve and then maintain a state of alertness and is associated with an alert system identified in frontal and parietal regions of right hemisphere. Secondly, **orienting** refers to the ability to select information from sensory inputs, in particular from location in visual space and is associated with regions of parietal and frontal lobes. Finally, **conflict resolution** is defined as the ability to solve conflicts among responses and is mediated by lateral prefrontal cortex and midline frontal areas (Fan et al., 2002).

distance, the asterisk (i.e, the cue) subtended a visual angle of 0.3°, the single flanker, namely the arrow or the little line, subtended a visual angle of 0.6°, whereas the whole stimulus composed by central arrow and lateral flankers subtended a visual angle of 2.8°. Stimuli and cues could be presented either 0.9° above or below the fixation point.

The sequence of events for each trial was as follows: firstly, a fixation point appears, for a variable duration (from 400ms to 1600ms), at the centre of the screen; secondly, it was followed by the presentation of the cue (one of the four types described above) that lasted for 100ms; thirdly, the end of cue presentation was followed again by the fixation point for 400ms; then, the stimulus was presented (above or below the fixation point) until participant's answered or for a maximum of 1700ms. After the practice session, three blocks of 96 trials were presented. Participants were asked to answer by clicking the left or the right button of the mouse accordingly to the direction of the target arrow.

The ANT provides information about alerting, orienting, and conflict resolution: the *alerting effect* is obtained by subtracting mean RTs of double cue condition from mean RTs of no cue condition; *orienting effect* by subtracting mean RTs of spatial cue condition from mean RTs of central cue condition; whereas *conflict resolution*, a type of executive control, by subtracting mean RTs of all congruent flankers from mean RTs of all incongruent flankers.

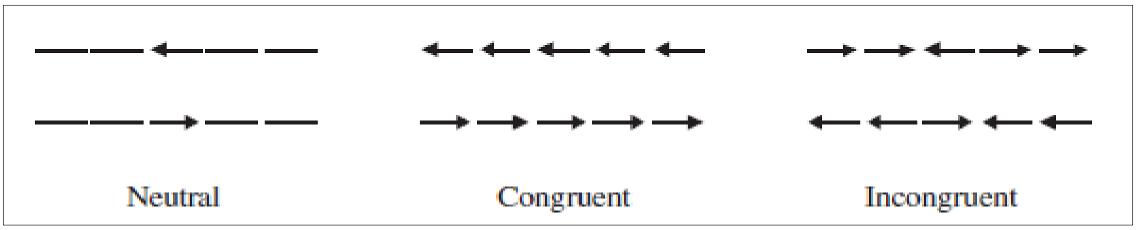

Figure 2.1 - Representation of flanker types, from Fan and colleagues (2002).

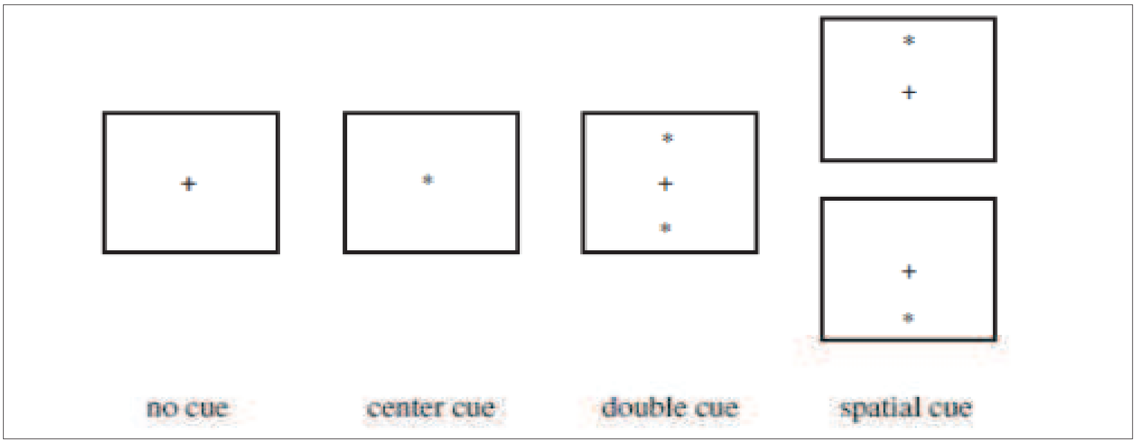

Figure 2.1 – Representation of cue types, from Fan and colleagues (2002).

❖ The Sustained Attention to Response Task (SART; Robertson, Manly, Andrade, Baddeley & Yiend , 1997) consists of the presentation of 225 single numbers (from 1 to 9) presented on the centre of the screen. The majority of these digits were no-target numbers (i.e., 1, 2, 4, 5, 6, 7, 8, 9), whereas a small percentage (4.9%) (Hu et al., 2012; Christoff, Gordon, Smallwood, Smith & Schooler, 2009) were target numbers (i.e., 3). Each number was presented for 1000ms, then followed by a blank screen for 1000ms; thus, time between one digit onset and the following one was 2000ms. Participants were required to respond to every no-target stimulus by pressing the spacebar of the computer keyboard, and to withhold key press to infrequent targets. Before the experimental session each participant performed a short practice session. Participants' performance at the SART (see Table 2.2) was analysed in terms of no-go error rates (i.e., erroneous answers to the target number derived by dividing the number of errors by 11, and then multiplying it by 100), reaction time coefficient of variability (RTCV; this is the variability in RTs in response to those no-target stimuli whose RTs were longer than 200 ms and was calculated by dividing the standard deviation of these RTs by their mean value [SD_{RTs}/M_{RTs}]), anticipations (those RTs to no-target stimuli that were shorter than 100ms, it was counted as number of occurrences), and omissions (i.e., instances of missing responses to no-target stimuli, it was counted as number of occurrences) (Cheyne, Solman, Carriere & Smilek, 2009). Additionally, mean RTs of the four trials before a target stimulus were compared depending on the correctness of the detection or on the erroneous answer in order to observe whether there is a difference in RTs before a correct detection or an error.

Measures	How to calculate	Description
% No-go error	((Number of errors) / 11)*100)	Erroneous answers to the target stimuli
RTCV	SD_{RTs}/M_{RTs}	SD_{RTs}/M_{RTs} of those no-target stimuli whose RTs are longer than 200ms.
Anticipation	Number of anticipations	RTs to no-target < 100ms
Omission	Number of omissions	Missing responses to no-target stimuli

Table 2.2 - Description of indices derived from SART (% No-go error, RTCV, anticipation, and omission).

In order to control foAr the quantity and quality of their states of MW and in line with previous findings showing that longer inter-probe intervals trigger more often states of MW (Seli, Carriere, Levene & Smilek, 2013), during the task the participants were shown nine thought probes (corresponding to 4% of the total stimuli) that were delivered at irregular intervals (Smallwood & Schooler, 2006). The probes were presented at irregular intervals within the ranges as described in Table 2.3. These probes provided information about the participants' mental state just before its presentation. Indeed, they could choose between the following options: 1. I was paying attention to the task; 2. I was aware of a state of MW; 3. I was unaware of a state of MW; 4. I was thinking about my performance at the task (a condition also known as "Task-Related Interference" [Sarason, Sarason, Keefe, Hayes &Shearin, 1986; Hu et al., 2012]); 5. Being in a state of "blank mind". At the end of the task, participants rated the difficulty and the level of interest perceived during the task. Five options were available for each question. As for the level of difficulty of the task, they could choose among the following possibilities: 1. Very simple; 2. Quite simple; 3. Neither easy nor difficult; 4. Quite difficult; 5. Very difficult. As for the level of interest raised by the task, they were presented with the following possibilities: 1. Not interesting; 2. A little interesting; 3. Interesting enough; 4. Pretty interesting; 5. Very interesting. It was then possible to derive a Percentage of MW episodes across the nine probes and separate ratios considering the percentage of times that the participants referred (1) on task, (2) aware of MW, (3) unaware of MW, (4) being in a "blank mind" state, and (5) thinking about the performance at the task. By allowing participants to define the contents of their thoughts, Schooler, Reichle and Halpern (2004) observed that many of them described task unrelated thoughts as thinking of nothing at all. Given that, we considered a general percentage of task unrelated thoughts (TUT) (derived by summing up the instances of being aware of MW, being unaware of MW, and being in a state of blank mind).

	Range
1° probe	20-30
2° probe	45-55
3° probe	70-80
4° probe	95-105
5° probe	120-130
6° probe	145-155
7° probe	170-180
8° probe	195-205
9° probe	225

Table 2.3 – Intervals of probe presentation. Range of presentation is intended as progressive sequence of items presentation.

2.3.3 – Cognitive Failure Questionnaire

The participants were also administered the Cognitive Failure Questionnaire (CFQ; Broadbent et al., 1982; Italian version, De Beni et al., 2008) (see Appendix). This is a questionnaire formed by 25 questions that explore the frequency of failures in perception, memory, and action in everyday life. Participants were asked to answer the questionnaire considering the frequency of such events over the previous 6 months. Each item was rated using a 5-point Likert scale (ranging from 0 "never" to 4 "very often").

2.4 – Results

The analysis of the data was performed through several steps. As a first step, in order to overcome the well-known problem of task impurity of executive tests (Miyake & Friedman, 2012; Miyake, Friedman, Emerson, Witzki & Howerter, 2000), we performed a Principal Component Analysis (PCA) on the scores obtained on the cognitive tasks. This allowed us to check for the presence of executive components that share the same part of covariance, rather than considering single cognitive tests. We then explored the participants' performance at the SART and the frequency of MW states during the task. As a third step, we ran a series of correlation analyses to investigate the association between states of MW and both general (i.e., cognitive) and specific (i.e., task difficulty and its perceived interest) domain factors. Finally, a regression analysis was performed considering those variables that were associated with MW in order to reveal which best accounted for the variance of MW episodes.

2.4.1 – Principal Component Analysis

A principal component analysis (PCA) was performed to explore the covariance between cognitive tasks examining executive functioning and attention. Specifically, Digit backward (number of sequences retrieved), Listening Span Task (number of correct words), Phonemic fluency, Stroop (Index of Time Interference), TMT_B-A, Alerting effect, Orienting effect, and Executive control were taken into consideration (see Table 2.4).

Measures	**Description**
Digit Backward	Total number of sequences retrieved correctly
Listening Span Task	Total number of words retrieved correctly
B-A (Trail Making Test - TMT)	Time (TMT-B) – Time (TMT-A)
Phonemic fluency	Total number of words correctly produced
Index of Time Interference (Stroop)	Time Incongruent Condition – ((Time Reading Condition + Time Naming Condition)/2)
Executive effect (ANT)	(Incongruent flankers) – (Congruent flankers)
Alerting effect (ANT)	(No cue condition) – (Double cue condition)
Orienting effect (ANT)	(Central cue condition) – (Spatial cue condition)

Table 2.4 – Summary of measures taken into consideration for the PCA.

The normality of the distribution of the scores was checked, and all measures were approximately normally distributed. The values of skewness and kurtosis were under the generally accepted values (skewness < 2; kurtosis < 4; see Kline, 1998; Unsworth & McMillan, 2014), with the exception of the Executive effect at the ANT that exceeded these values. For this reason, we calculated the z-scores of Executive control at the ANT and only one was eliminated. Its elimination from the dataset made the data approximately normally distributed.

Measures	Range	M (SD)	Skew	Kurtosis
Digit Backward	4 – 13	7.52 (2.35)	.40	-.56
Listening Span Task (number of words)	19 – 37	28.09 (4.64)	-.06	-.70
B-A (Trail Making Test)	9 - 107	36.58 (19.77)	1.49	3.20
Phonemic fluency	11 - 53	31.72 (8.62)	-.061	.041
Index of Time Interference (Stroop)	2 - 28	10.01 (4.85)	1.49	3.98
Executive effect (ANT)	28.56 – 203.48	79.55 (31.82)	1.20	2.72
Alerting effect (ANT)	-3.60 – 138.54	43.44 (25.17)	1.00	2.47
Orienting effect (ANT)	4.06 – 110.52	57.11 (23.06)	-.149	-.42

Table 2.5 – Descriptive statistics of the distribution of the cognitive scores.

The suitability of data for factor analysis was assessed before running the PCA. The correlation matrix revealed coefficients of .3 or above. The Kaiser-Meyer-Oklin value was (.668), and the Bartlett's Test of Sphericity (Bartlett, 1954) was statistically significant. The first six eigenvalues were 2.45, 1.41, 1.11, .79, .67, .64. The scree test suggested to explore up to 3-components.

The 3-component solution (see Table 2.6) accounted for 62.18% of the total variance. After Varimax rotation, this solution yielded a first component, labeled **Executive functioning** (28.48% of the accounted variance), that included Listening span task, Phonemic fluency, B-A, Index of Time Interference, and Digit backward. The second component, labeled **Ineffectiveness of attentional executive control** (18.05% of the accounted variance), included Orienting and Executive effects at the ANT. Finally, the third component, labeled **Alerting**, accounted for 15.64% of the variance.

Component Transformation Matrix

	Component		
	1	2	3
Listening Span Task (number of words)	**.727**	-.182	-.173
Phonemic fluency	**.718**	.233	.042
B-A (Trail Making Test)	**-.696**	.021	-.271
Index of Time Interference (Stroop)	**-.682**	.208	.244
Digit backward	**.501**	-.481	.059
Orienting effect (ANT)	.058	**.828**	.118
Executive control (ANT)	-.153	**.628**	-.533
Alerting effect (ANT)	-.088	.040	**.886**

Table 2.6 – The three-factor solution after Varimax rotation. Factor 1: Executive functioning; Factor 2: Ineffectiveness of attentional executive control; Factor 3: Alerting.

2.4.2 – Mind Wandering and SART performance

Normality of distribution of MW frequency and indices of SART have been checked and each variable was approximately normally distributed. Also in this case values of skewness and kurtosis were within the generally accepted range (i.e., skewness < 2, and kurtosis < 4), with the exception of % Blank mind that exceeded the accepted range. Subsequently the z-scores for the % of Blank mind states was calculated. In this case two raw scores were eliminated. Table 2.7 shows means and standard deviations. The participants reported to be aware of MW states on 27.18% of cases (SD = 23.32%), unaware of MW on 7.35% (SD = 9.06%), in a state of blank mind on 7.58% (SD = 10.14%), and in a task related interference on 11.96% (SD = 12.16%). Additionally, task unrelated thoughts (TUTs) were reported in 43.59% of cases (SD = 26.08).

Measures	Range	M (SD)	Skew	Kurtosis
% On task	0 – 88.8	44.4 (23.9)	.20	-.47
% TUT	0 – 100	43.59 (26.08)	.15	-.70
% Aware of MW	0 – 100	27.18 (23.32)	.85	.48
% Unaware of MW	0 – 44.44	7.35 (9.06)	1.60	3.71
% Blank mind	0 – 44.44	7.58 (10.14)	1.47	2.16
% TRI	0 – 44.44	11.96 (12.16)	.80	-.05

Table 2.7 – Descriptive statistics of MW frequency. Note: TUT=Task-unrelated thoughts; TRI=Task-related interference.

Considering time on task, frequencies of different types of MW reported as a group are presented in Table 2.8.

	Probe								
	P1	P2	P3	P4	P5	P6	P7	P8	P9
% On Task	64.6	46.2	43.1	36.9	49.2	36.9	30.8	47.7	44.6
% Aware of MW	10.8	27.7	35.4	26.2	18.5	30.8	33.8	29.2	32.3
% Unaware of MW	4.6	7.7	3.1	7.7	12.3	10.8	6.2	6.2	7.7
% Blank mind	4.6	1.5	7.7	15.4	15.4	7.7	13.8	9.2	6.2
% TRI	15.4	16.9	10.7	13.8	4.6	13.8	15.4	7.7	9.2

Table 2.8 – Percentage of mental states reported during the SART. Note: TRI=Task-related interference.

Figure 2.3 shows that there is a prevalence of mental states described as On task and Aware of MW. An initial qualitative analysis of time on task considered the first half and then the second half of the task. At the beginning of the task there was a prevalence of mental states defined as On task whose values tend to decrease in favour of an increase in instances of Aware of MW. At half of the tasks there was a reversal trend, indeed an increment of On task mental states was observed. It has been hypothesized that this further rise of On task mental states might be related to having realized of having been too distracted (high percentage of aware of MW). The second half of the task was similar to the first one, indeed a same trend as in the first half was observed. As regard to the other mental state definitions, they were characterized by low frequency and were fairly constant throughout the task.

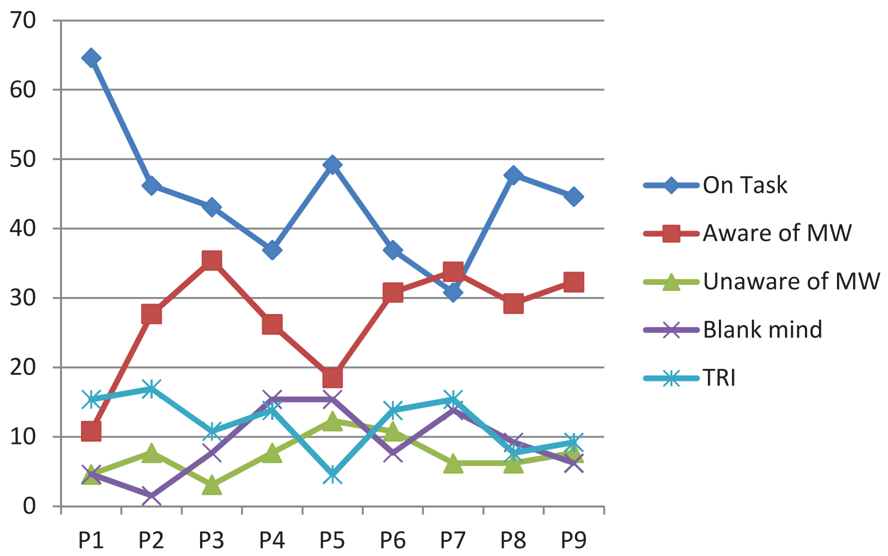

Figure 2.2 – Percentage of mental states reported during the task. Note: TRI=Task-related interference

Only % No-go errors and RTCV were taken into consideration, whereas anticipations and omissions were not considered for further analysis because the majority of participants did not make such mistakes, indeed 61 out of 65 participants made 0 omissions, and 63 out of 65 made 0 anticipations. Table 2.9 presents descriptive statistics about SART measures, values of skewness and kurtosis were within the generally accepted range (i.e., skewness < 2, and kurtosis < 4).

The mean rate of no-go errors (target) was 22.24% (SD = 14.73%). The mean RTCV was 195.23 ms (SD = 55.97).

Measures	Range	M (SD)	Skew	Kurtosis
% No-go errors	0 – 81.81	22.24 (14.73)	1.03	2.91
RTCV (ms)	114.00 – 351.25	195.23 (55.97)	.90	.36

Table 2.9 – Descriptive statistics of measures derived from SART. RTCV=Reaction time coefficient of variability. Note: RTCV=Reaction time coefficient of variability.

Interestingly, the mean RTs for the four trials before a no-go error (M = 454.69, SD = 59.91) were significantly shorter than the mean RTs for the four trials before a correct detection (M = 483.45, SD = 62.90) ($F = 25.129$, $p < .001$) highlighting an acceleration before a No-go error. Moreover, we aimed at comparing the mean RTs when different mental states were experienced (i.e., aware of MW, unaware of MW, blank mind, and TRI), unfortunately, a very small amount of participants experienced all kinds of thoughts preventing any further analysis. Furthermore, the indices of SART % No-go errors and RTCV were significantly correlated ($r = .256$, $p = .039$) (see also Cheyne et al. [2009] for similar results). Additionally, measures of SART were significantly correlated with the frequency of MW episodes confirming the reliability of what was reported by participants when probes were presented. Specifically, RTCV was positively correlated with % TUTs ($r = .306$; $p = .013$), and negatively correlated with % On Task ($r = -.344$; $p = .005$). Thus, the variability of RTs increased with the increment of percentage of thoughts that were unrelated to the task, independently on the differentiation of mental state; whereas the more frequently participants reported to be on task, the more constant were their RTs. On the other hand, by considering the % No-go errors, a significantly positive correlation was observed with % Unaware of MW ($r = .246$; $p = .048$), and % TRI ($r = .271$; $p = .029$). Thus, the positive correlation between % TRI and % No-go errors suggested a tendency to think about performance as a consequence of errors during task performance (see Table 2.10). Moreover, it was shown that higher frequency of No-go errors led to rate task level difficulty as higher (r = .301; p = .015). The last to be considered was the total score obtained at the CFQ, a questionnaire about cognitive failures in everyday life. It was observed that the association between the behavioural index of RTCV, that seemed to mirror the tendency to remain on task or let the mind wander during the SART, and the total score of CFQ approached the significance (r = .237; p = .057) providing further evidence to the hypothesis about MW conceptualized as a stable cognitive characteristic across contexts.

	%No-go errors	RTCV
% No-go errors	-	
RTCV	**.256***	-
% TUT	-.098	**.306***
% On Task	-.031	**-.344****
% Aware of MW	-.142	.231
% Unaware of MW	**.246***	.156
% Blank mind	-.106	.049
% TRI	**.271***	.021
Difficulty perceived	**.301***	.080
Interest in the task	-.111	-.101
CFQ	.117	.237

Table 2.10 – Correlation analysis between SART measures and MW frequency. Note: RTCV=Reaction time coefficient of variability; TUT=Task-unrelated thoughts; TRI=Task-related interference, CFQ=Cognitive Failures Questionnaire. * $p < .05$, ** $p < .01$.

2.4.3 – Correlation analysis

The relation between MW and the cognitive components emerged from the preliminary PCA was explored by using Pearson product-moment correlation coefficient (see Table 2.11). No significant correlation was observed with % TUTs. Considering separately the different MW reported states (i.e., % Aware of MW, % Unaware of MW, % Blank mind, and % TRI), % Aware of MW was positively correlated with Executive Functioning ($r = .283$; $p = .024$) showing that who reported more frequently to let their mind wander deliberately were those who scored higher in executive functioning. Other correlations were not significant; however, a trend was observed between Executive functioning and % Unaware of MW ($r = -.224$; $p = .075$), thus an opposite tendency compared to the relation with % Aware of MW. Moreover, specific domain factors, such as difficulty and interest in the task, were taken into consideration. We found a negative correlation between the level of interest for the task and the % of TUTs ($r = -.281$; $p = .023$) suggesting that level of interest reported at the SART was related to the tendency to let the mind wander, independently of type of MW reported at the probe. As last, MW during the SART (i.e., % TUTs) was significantly correlated with total score of CFQ ($r = .269$; $p = .030$) revealing an association between MW during a laboratory task and failures in everyday life (see Table 2.11).

	Executive Functioning	Ineffectiveness of attentional executive control	Alerting	Difficulty perceived	Interest in the task	CFQ
Difficulty perceived	-.095	-.030	-.139	-		
Interest in the task	-.110	.117	-.105	.006	-	
CFQ	-.062	.140	-.083	.153	-.111	-
% TUT	.106	.020	.163	-.060	**-.281***	**.269***
% On task	-.035	-.106	-.166	.055	.240	**-.286***
% Aware of MW	**.283***	.108	.219	-.098	-.229	.213
% Unaware of MW	-.224	-.059	-.050	.074	-.133	.047
% Blank mind	-.059	-.121	.135	.138	-.083	.125
% TRI	-.158	.167	-.023	.020	.131	-.015

Table 2.11 – Correlations between task independent factors (i.e., the cognitive components), task dependent variables (i.e., Perceived Difficulty and Interest on the task) and MW episodes. Note: CFQ=Cognitive Failures Questionnaire; TUT=Task-unrelated thoughts; TRI=Task-related interference. * $p < .05$

2.4.4 – Regression analysis

To further investigate whether specific factors (such as the interest in what it is being done, or a general tendency to perceive the cognitive failure during everyday life) can explain the occurrence of MW states, a multiple regression analysis was conducted. Those variables that were observed as being significantly correlated with MW episodes, namely Executive Functioning, Level of interest, and CFQ, were entered as independent variables in order to investigate which of these variables might influence more the tendency to drift attention, either considering it globally (TUTs) or separately (aware of MW, unaware of MW, blank mind, TRI). Considering % TUTs as dependent variable, the analysis showed that, together, the predictors accounted for a significant part of variance of % TUTs ($R^2 = .160$, $F(3,60)= 3.813$ $p = .014$). Furthermore, significant predictors of this model were CFQ total score (ß = .245, p = .044) and Level of interest, (ß = -.272, p = .027) (see Table 2.12).

	Partial Correlation	ß	Sig.
Executive Functioning	.098	.091	.448
Level of interest	-.281	-.272	.027
CFQ total score	.256	.245	.044

Table 2.3 - Summary of the results of the multiple regression analysis for the variables predicting % TUTs (task-unrelated thoughts). Note: CFQ=Cognitive Failures Questionnaire.

Hereinafter, MW episodes are analysed separately in order to assess whether being aware or being unaware of thinking about aspects unrelated to the task at hand, or mind blanking or still thinking about quality of performance are accounted for by different factors.

Considering % Aware of MW as dependent variable, the multiple regression model accounted for a significant part of the variance (R^2 = .172, F(3,60) = 4.150 p = .010). Furthermore, Executive Functioning was found as a significant predictor accounting for a unique contribution to this model (ß = .274, p = .024) (see Table 2.13).

	Partial Correlation	ß	Sig.
Executive Functioning	.286	.274	.024
Level of interest	-.210	-.198	.101
CFQ total score	.221	.208	.085

Table 2.4 - Summary of the results of the multiple regression analysis for the variables predicting % Aware of MW. Note: CFQ=Cognitive Failures Questionnaire.

On the other hand, by considering % Unaware of MW as dependent variable, the multiple regression model was not significant (R^2 = .073, $F(3, 60)$ = 1.582 p = .203); however it should be mentioned that Executive Functioning approached to explain a significant part of the variance (ß = -.240, p = .061). Furthermore, concerning % TRI, results showed that predictors do not explain significant part of variance of % TRI (R^2 = .045, $F(3, 60)$= .935 p = .429). Similarly, predictors did not explain variance of % Blank mind (R^2 = .028, $F(3, 58)$ = .558 p = .645).

2.5 – Discussion

This study aimed at investigating, as first, the frequency of different types of MW mental states, as second, their effects on task performance, and, as third, the cognitive underpinnings of MW episodes as differently defined (i.e., Aware of MW, Unaware of MW, Blank mind), and TRI.

As first, the SART was administered to explore MW frequency during a low demanding attention task. A low demanding task, such as a task with low probability of target appearance, is thought to trigger MW states given the monotony and repetitiveness of the task that easily becomes automatic. The participants had the possibility to characterize MW episodes by choosing between On task, Aware of MW, Unaware of MW, Blank mind, and TRI. The analyses took into consideration MW both as a unitary construct (i.e., TUTs) and as different types of MW episodes (i.e., considering Aware of MW, Unaware of MW, Blank mind), and TRI. Results showed that, coherently with previous studies (McVay & Kane, 2009; Smallwood, Obonsawin & Reid, 2003; Smallwood, Riby, Heim & Davies, 2006), MW tends to increase with time on task. A qualitative analysis highlighted that there is a prevalence of mental states described as Aware of MW. We would like to stress here that according to the context regulation hypothesis (Smallwood & Andrews-Hanna, 2013), MW occurrence might change depending on demanding level of the task at hand. In line with this hypothesis, during an undemanding task like the SART, participants might have left their mind wander deliberately because of the few resources required by the task.

As second, one limitation of MW measurement concerns the problem that it relies on self-reported MW. However, the association between objective measures, such as SART indices, and what participants reported overcome this limitation. The analysis of the relation between MW rates and performance at the SART, as measured by the indexes of RTCV and %No-go errors, revealed an association between RTCV and % TUTs. This result suggests that regardless of the type of MW state, RTCV apparently mirrors an attentional focus not permanently directed on the task; thus, it might be considered as a global index of the ability to keep the concentration on the task. Differently from what has been just described, the % No go errors appeared to be more specific and sensible to the different types of MW. Indeed, a positive correlation was observed with % Unaware of MW, and with % TRI. It might be speculated that being unaware of our thoughts may lead to automatically continue to press the key despite target presentation which implies no key press. As stated by Schooler (2002), lacking of meta-awareness may determine a temporal dissociation between experience and meta-consciousness. This could determine a great number of errors. As a consequence of such errors, participants might evaluate their performance and make some considerations about it. This evidence confirms the necessity of distinguishing between the different states of MW rather than considering MW as a unitary construct.

As third, the cognitive underpinnings of MW episodes as differently defined were assessed. The cognitive tasks proposed were analysed by applying a PCA in order to explore the covariance between cognitive measures taken into consideration. As shown in Table 2.6, the PCA suggested the existence of three main components: Executive Functioning, Ineffectiveness of attentional executive control, and Alerting. It is interesting to note that, differently from what was expected, the first component included the Listening Span Task (number of words), Phonemic fluency, B-A, Index of Time Interference (Stroop), and Digit backward. Thus, it included measures of working memory, shifting, and inhibition. This result provided further confirmation to the task impurity problem of tasks assessing executive functions (Miyake & Friedman, 2012; Miyake et al., 2000). Indeed, Stroop interference is usually considered as a measure of inhibition (e.g., Cain, Silva, Chang, Ronda & Duffy, 2011; Gyurak et al., 2009; Tsutsumimoto, Makizako, Shimada, Doi & Suzuki, 2015). Similarly, the Listening span and the Digit backward tasks are usually considered as measures of updating of working memory (e.g., Borella, Carretti & De Beni, 2008; Tsutsumimoto et al., 2015), whereas Phonemic fluency and B-A are taken to measure flexibility and shifting (e.g., Gyurak et al., 2009; Tsutsumimoto et al., 2015). Considering that the executive functions operate on other cognitive processes, a portion of the variance of the task is not necessarily measuring the intended executive process. For example, in TMT part B individuals are not only required to shift from letters to numbers, but need also to keep the last stimuli in mind and inhibit the following numbers or letters in favour of shifting to number or letter according to the situation. Accordingly to these considerations and to the results of this experiment, that show that measures known as tapping a specific executive component loaded on the unique Executive Functioning component emerged, the Executive Functioning component may indicate the common processes that underlie the three executive components. This is known as the "unity" aspect of the executive functions (Miyake et al., 2000). The remaining two components emerged from the PCA were Ineffectiveness of attentional executive control, and Alerting. The former is composed by orienting effect and executive control, derived by ANT, suggesting that the ability to allocate attention might interfere with the behavioural executive control. On the other hand, the latter was only composed by the alerting effect derived by the ANT.

Further step in the analysis consisted of exploring the cognitive underpinnings of MW states. This part of the study was of main interest; indeed, the aim was to attempt an exploration not only about the relation of different types of MW reported with cognitive aspects, but also with the experience of cognitive failure during everyday life in order not to limit results to laboratory. When considered as a unitary construct (i.e., TUT), the general tendency to lose the focus of the task at hand in favour of unrelated thoughts might be explained by interest in the task and by the total score obtained at CFQ. It is noteworthy that asking participants to provide precise information about MW episodes allowed us to observe that general and specific domain factors may play different roles. Completely different results were observed when different states of MW were considered separately. Indeed, executive resources seemed to play an opposite role in explaining variance of those episodes that are reported as aware or not. Previous studies emphasized the importance of distinguishing between intentional and unintentional MW (Seli, Risko & Smilek, 2016b). About that, Seli, Risko, Smilek and Schacter (2016) stated that intentional MW is characterized by consciousness, whereas unintentional MW by lacking of conscious initiation. According to this suggestion, results of this study seemed to shed some light on the debate about the role played by executive resources. Indeed, the decoupling hypothesis (Smallwood & Schooler, 2006) states that the train of thoughts requires executive resources to persist. On the contrary, the executive failures hypothesis (McVay & Kane, 2009) posits that this train of thoughts is a consequence of an executive failure in inhibiting irrelevant thinking while performing a task. However, it should be underlined that these theoretical considerations were based on considering MW as an unique construct. We found that higher executive resources were positively associated with aware of MW. Additionally, executive resources showed the opposite relation with unaware of MW, indeed lower executive resources accounted for variance of unaware of MW, even though this relation only approached significance level. Overall, these findings suggest that different levels of executive functioning might drive the tendency to be aware or to lose awareness of our mental experience providing further evidence to the necessity of distinguishing MW states rather than considering it as an unique construct. Indeed, results of this study underlined a different cognitive nature of MW states. Future studies should increment the number of participants and distinguish between different MW episodes by considering the conceptual difference between them in order to better understand the phenomenon of MW. In addition to general domain factors, such as executive functioning, even specific domain factors may play a role in explaining the phenomenon of MW. It is well known the association between level of interest and the attention paid to what it is doing at the moment, for example readers that were more interested in the topic of reading text focused better their attention on what they were reading (Hidi, 2001). Unsworth and McMillan (2013) observed that interest plays a main role in influencing motivation that was shown to predict task unrelated thoughts. In our study participants were asked to rate their interest in the task after its completion. Interestingly, states of MW were significantly more infrequent when the task was considered interesting. It has been proposed that MW might be related to the need to relieve from boredom (Mooneyham & Schooler, 2013; Smallwood & Schooler, 2015). Our results might be, at least in part, explained by this possibility. As last to be discussed, there is evidence that MW is a cognitively stable characteristic, indeed studies observed such trend across different contexts (Burdett et al., 2016; McVay, Kane & Kwapil, 2009). Consistently, this study showed that the tendency to let the mind wander during a laboratory task performed on a laptop was related to the occurrence of cognitive failures in everyday life. So, such relation between what occurs in daily life and what occurs during a laboratory task may suggest the ecological validity of tasks performed in laboratory, at least in simulating boredom and automaticity.

Chapter 3

Mind Wandering in the language domain: An experimental investigation

3.1 – Introduction

As shown in Chapters 1 and 2, *mind wandering* (MW) represents a shifting of attention from a primary task. As such, it reflects a breakdown in the ability to attend the here and now leading to a superficial processing of incoming stimuli. A relevant issue which still awaits clear answers concerns the impact of such decoupling of attention on the ability to process complex linguistic information at the narrative level. Namely, the research described in this Chapter aimed at investigating whether a general tendency to lose the track of the task at hand can be observed on tasks of sustained attention and during discourse production. Discourse is defined as a sample of oral language that "goes beyond the boundaries of isolated sentences" (Ulatowska & Olness, 2004; p. 300). In order to generate an accurate and well-formed narrative discourse both microlinguistic (i.e., lexical and grammatical) and macrolinguistic (i.e., pragmatic and discourse) knowledge need to be integrated (Marini, Carlomagno, Caltagirone & Nocentini, 2005).

Narrative production tasks require participants to generate a story characterized by a beginning and an ending; they must describe events that unfold over a timeline. As such, narrative discourse can be considered as a sort of goal-directed thinking or action similar to complex structured event knowledge (Wood, Knutson & Grafman, 2005;

Ylvisaker, Szekeres & Feeney, 2008). Additionally, narratives are considered as being cognitively based and structured following a set of rules that is known as story grammar. The story grammar knowledge does not depend on message contents, rather it relies on the knowledge about schemas and regularities in the story structure that may help speakers in guiding linguistic production (Coelho, 1998; Merritt & Liles, 1989; Stein & Glenn, 1979) because they explain the temporal and causal relationships among characters and events (Coelho, 2007). These regularities are described as episode components that are logical and not referred to a specific content such as goals, attempts to achieve such goals, and the consequences of these attempts (Stein & Glenn, 1979). From a theoretical point of view, story grammar is associated to executive functions; indeed, considering the complexity of discourse production, it has been hypothesized that the three dimensions of executive functioning described by Miyake and colleagues (2000), namely shifting, updating, and inhibition, may play a role in discourse production. According to Mozeiko, Le, Coelho, Krueger and Grafman (2011), shifting may be necessary for the generation of new episodes, updating may be involved in keeping track of previously provided concepts and in integrating incoming information, while inhibition may be necessary for refraining from the introduction of irrelevant pieces of information that might lead to the production of tangential utterances. In recent years, a number of clinical studies have shown that the narrative productions of persons with traumatic brain injuries (TBIs) are characterized by macrolinguistic difficulties (e.g., violations of global coherence) that made their discourse inadequate, vague and confused (Marini, Galetto et al., 2011; Carlomagno, Giannotti, Vorano & Marini, 2011). Moreover, individuals with TBI scored lower than controls on measures of story grammar abilities (Mozeiko et al., 2011) providing evidence of their difficulty to organize information in a well-structured manner characterized by a logical relationship between people and events. Further analyses have revealed a correlation between story grammar measures and inhibition, which is one of the afore-mentioned executive components (Mozeiko et al., 2011). More recently, Marini, Zettin and Galetto (2014) observed an association between macrolinguistic difficulties (i.e., local and global coherence errors) and levels of informativeness and executive skills. It seems, then, that executive functions are relevant in organizing narrative episodes and in producing efficient narratives by means of cohesive and coherent ties.

Message production is likely a multistage process (e.g., Indefrey & Levelt, 2000) whose characteristics are still far from clear. However, some insights are provided by the Structure Building Framework (SBF; Gernsbacher, 1990), a model originally proposed to outline processes of discourse comprehension but that has been applied also to interpret discourse production (Gernsbacher, Tallent & Bollinger, 1999). According to this model, building mental representations requires three main processes: laying a foundation, mapping, and shifting. A critical role is likely played by a prelinguistic conceptual phase where the speaker, through a process of foundation laying, generates a structure or mental depiction of the story that will serve as a foundation for its development. As the information flows, (s)he needs to continuously monitor its consistence with the generated structure(s). If it is not consistent, then the speaker needs to shift in order to generate a new structure. Over time, the speaker will generate several structures and will need to map all subsequent pieces of information in the appropriate structures. These structures eventually trigger the generation of propositions organized at the macrolinguistic level by means of adequate coherent and cohesive links among the utterances. These processes likely rely on cognitive skills such as executive functions and attention (needed to monitor the ongoing generation of the narrative inhibiting irrelevant information and shift from one structure to the other) as well as verbal memory (necessary for laying a foundation and mapping during the generation of a narrative discourse as suggested in Coelho et al. 2013).

In line with these premises, the study described in this Chapter aims at investigating whether the ability to stay on task during an attention task and the ability to communicate effectively, namely convey relevant information without grammatical errors or pragmatic errors such as not precise referents, repetitions, fillers, conceptual errors, or tangential utterances, are somehow related as a general tendency to stay on task without losing the track of the task at hand.

3.2 - Aims of the study[5]

There is no evidence of studies that explored the relationship between a wandering mind and narrative discourse production. We assumed that the ability to convey correct and relevant information, inhibiting the inclusion of topic that might be considered as derailing, could be considered as an ability to stay focused on task. The aims of the present study were to investigate (1) whether the ability to stay on task during an attention task and the ability to communicate effectively, conveying relevant information, are related, and (2) whether it was possible to identify a general index of derailment from the purpose of what it is being done (considering the SART, the Cognitive Failures Questionnaire as a representative measure of daily life, and the narrative discourse production task) which could be explained by the role played by Executive Functioning. As a preliminary step in the analysis, a Principal Component Analysis (PCA) was performed on a set of variables derived by using a multi-level approach to discourse analysis (Marini, Andreetta, del Tin & Carlomagno, 2011). The PCA would allow to examined the relation between microlinguistic and macrolinguistic

[5] The experiment described in this Chapter and in Chapter 2 are part of a wider research involving 65 participants.

aspects in order to identify a factor that would provide information about communicativeness. As the first issue, the relation between the reaction time coefficient of variability (RTCV) of the SART, that seemed to reflect an ability to stay focused on the task or not, and the components identified by performing a PCA on narrative variables was explored. As the second issue is concerned, a further PCA was performed in order to investigate whether executive resources may explain a general tendency to stay on task without losing the tracking of the task at hand (by considering RTCV, the CFQ, and the communicativeness, as representative of this aspect).

3.3 – Methods

3.3.1 – Participants

The same 65 healthy young adults (Age: M = 22.18; SD = 3.4; Educational level: M = 13.86; SD = 1.9; Gender distribution: F = 49; M = 16) recruited for the study described in Chapter 2 participated also to this investigation.

3.3.2 – Narrative task

A story telling task was administered in order to investigate participants' narrative abilities. Participants were asked to produce a narrative description of what was portrayed in two cartoon stories consisting of six pictures each: the "Flower Pot" (Figure 3.1) (Huber & Gleber, 1982), and the "Quarrel" (Figure 3.2) (Nicholas & Brookshire, 1993).

Participants could see these images until they finished their description in order to avoid interference of short-term memory, and were told that they could talk as long as they wanted. Narrative productions were audio-recorded, and then transcribed *verbatim* including phonological fillers, pauses, false starts, and extraneous utterances (Marini, Andreetta, del Tin & Carlomagno, 2011). The transcribed language samples were segmented into utterances according to acoustic, semantic, grammatical, and phonological criteria (Marini, Andreetta et al., 2011):

- *Acoustic criterion*: utterances are considered as an emission of sounds between pauses that can be easily detected. More precisely, pauses are considered as breaks of more than 2 seconds that determine segmentation into different utterances. For example, the following sequence of information would be segmented as follows:

/There is a man...(3 seconds) / who is angry /

- *Semantic criterion*: an utterance provides information that is conceptually homogeneous and consists of the main predicate and the associated arguments (Olness, Matteson & Stewart, 2010). Therefore, in case of no acoustic interruptions, utterance boundaries can be established whenever a different proposition is produced (see example 1). Moreover, when the proposition is not complete and the semantic concept is reformulated, utterance has to be segmented in 2 different ones (see example 2). For example, the following sequence of information would be segmented as follows:

(1) / There is a man who is walking on the sidewalk / He is with his dog when suddenly a flower pot falls on his head /

(2) / There is a man who is / who is walking on the sidewalk /

- *Grammatical criterion*: in case of no acoustic or semantic criterion, an utterance can be divided considering grammatical aspects. A well-formed sentence can include subordinate clauses, in this case it has to be considered as a single one (see example

1), on the other hand in case of two coordinate clauses they have to be segmented in 2 different utterances (see example 2).

(1) / A man is walking on the sidewalk when a flower pot suddenly falls on his head /

(2) / A man is walking on the sidewalk / and a flower pot falls on his head /

- *Phonological criterion*: whenever a word pronunciation is interrupted (i.e., false start) a utterance segmentation is counted.

/ There is a man who is wa- / walking on the sidewalk /

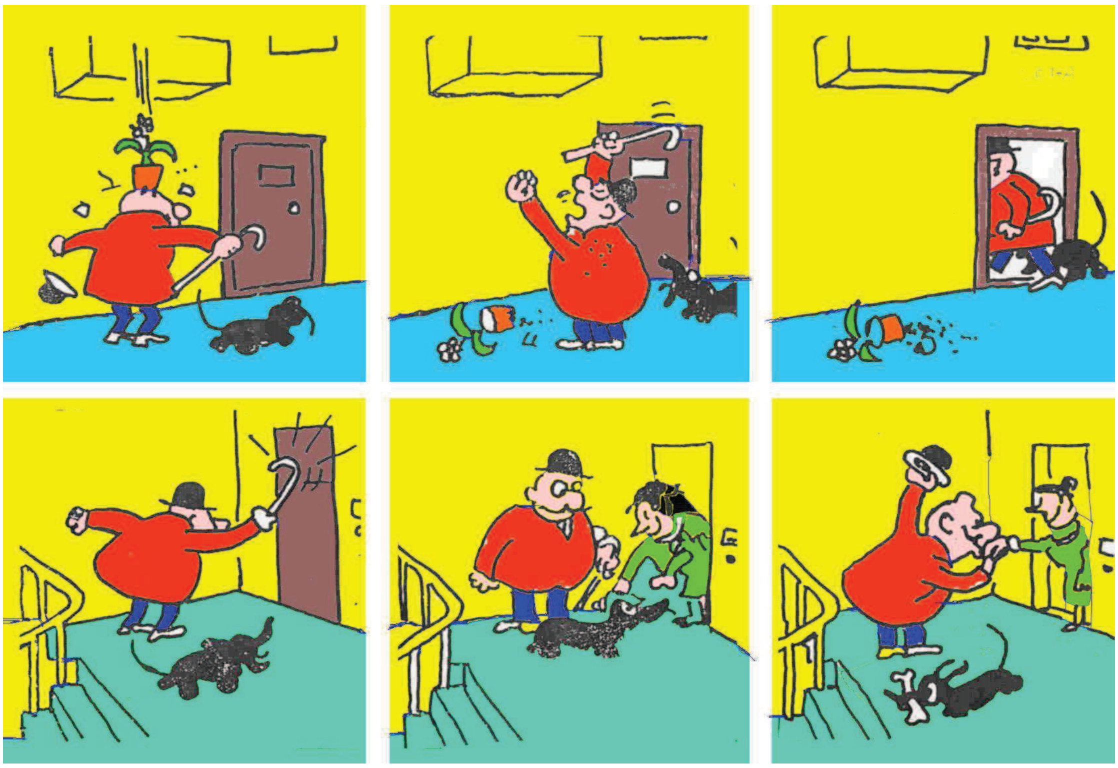

Figure 3.1 – "Flower pot" picture.

Figure 3.2 – “Quarrel” picture.

The analysis of narrative productions focuses on the following aspects: productivity, lexical and grammatical processing, narrative organization, and informativeness (Marini, Andretta et al., 2011).

Productivity: Productivity measures the amount of discourse produced. It is measured by number of units, number of words, speech rate, and the mean length of utterance (MLU).

Units represent the total number of verbalization produced by each participants, including even not-well-formed words such as phonological paraphasias, neologisms, or false starts. Afterwards, total number of words includes only well-formed words, excluding false starts, phonological paraphasias, and neologisms. Number of words is necessary to calculate speech rate as measured by words per minute. Considering utterances segmentation criteria described above, total number of utterances can be counted in order to determine MLU that is calculated by dividing the number of words by the number of utterances. This measure provides information about mean sentence length.

Lexical processing: Lexical measures include percentage of semantic and verbal paraphasias, of paragrammatic errors, and of phonological errors.

Lexical processing consists of the ability to select words appropriate from a semantic point of view and this information can be derived calculating the percentage of semantic and verbal paraphasias. This percentage is calculated by dividing the number of verbal and semantic paraphasias by the total number of words produced, and then multiplying it by 100.

The percentage of paragrammatic errors provides information about the ability to access morphological and morpho-syntactic aspects. It is calculated by dividing the number of paragrammatic errors by the total number of words, and then multiplying it by 100.

Phonological skills are quantified by calculating the percentage of phonological errors, namely by dividing the total number of phonological errors by the total number of units, and then multiplying it by 100.

Grammatical processing: Grammatical measures include percentage of complete sentence, and of omission of morpho-syntactic information.

As mentioned before, a sentence is formed by a predicate and all its arguments, therefore all arguments required by a word have to be inserted in order to considered the sentence complete from a grammatical point of view. In addition, no omission or substitution of morpho-syntactic information have to be counted into the sentence. Thus, the percentage of complete sentence is calculated by dividing the number of sentence grammatically well-formed by the total number of sentences counted, and then multiplying it by 100 (Saffran, Berndt & Schwartz, 1989; Thompson, Shapiro, Tait, Jacobs & Schneider, 1996). As last, the percentage of omission of morpho-syntactic information is derived by dividing the amount of omission of morpho-syntactic information by the number of utterances, and then multiplying it by 100.

Narrative organization: Narrative organization is defined considering number of errors of cohesion, of local coherence, and of global coherence.

Cohesion is defined as the connectivity across following utterances through cohesive ties (Coelho, 2007). A percentage of cohesive errors will be considered by dividing the number of cohesive errors by the number of utterances, and then multiplying it by 100. Cohesive errors are aposiopesis, and the misuse of cohesive ties. Specifically, aposiopesis (Haravon, Obler & Sarno, 1994) represents a sudden interruption of the speech flow which is immediately resumed completing information just introduced. An example of aposiopesis is: / the man is staring at.. / the man is watching the dog /. The first utterance is interrupted abruptly (error at macro-linguistic level), but morpho-syntactic information is also missing, thus an error of content omission is also counted (error at microlinguistic level). On the other hand, misuse of cohesive tie consists of anaphoric pronouns (pronoun that refers to something mentioned before), errors in number or gender agreement between pronouns or noun phrases across utterances, and improper use of cohesive function words.

Coherence refers to the organization and maintenance of discourse topic beyond the single utterance. It may be considered either at local or global level. The former regards the connection of concept proposed in an utterance to the following one, whereas the latter refers to the global organization of the discourse according to the general goal and topic (Glosser & Deser, 1990; Coelho, 2007; Marini, Andreetta et al., 2011). Local coherence errors are represented by missing and ambiguous referents, and topic shift. About referents, missing one indicates that the referent is not provided, thus the listener does not know to whom the verb refers to. On the other hand, the ambiguous one indicates that in the utterance there is a referent to whom the verb refers to in an ambiguous way, thus it is not clear. For instance: / The man is walking on the sidewalk / then they enter the building /. It is not clear to whom "they" refers to. The third type of error is the topic shift, it occurs whenever an utterance is suddenly interrupted and the following one introduces new information without completing the topic previously introduced. For example: / He is reading the... / she is angry with him /. The percentage of local coherence errors is calculated by dividing the total number of local coherence errors by the total number of utterances produced, and then multiplying it by 100. About global coherence errors, they include tangential, conceptually incongruent, repetitive, and filler utterances (Christiansen, 1995). A tangential utterance is a derailment from the topic at hand; for example, in the description of the Quarrel picture: / Husband and wife are quarrelling / sometimes happens even to me /. The second utterance is considered as tangential because it is not strictly related to the task and such information is irrelevant, indeed participant started to talk about that because of the figure presented. As conceptually incongruent utterances are considered those utterances that provide information not directly presented in the figure. For instance, describing the Flower pot picture: / It is a sunny day / the man is walking alone /. The second utterance is conceptually wrong because the man is walking with his little dog in the picture stimulus. A repetition is considered as the utterance in which information already provided is repeated: / The man has a walking stick / he has a walking stick /. As last, a filler utterance is an utterance in which no additional information is provided, and who is speaking reflects about the story. For example: / The man and the woman are quarrelling / and now? / ah, yes /. The second and third utterances are comments or reflection of the speaker. The percentage of global coherence is calculated by diving the total number of global coherence errors by the total number of utterances produced, and then multiplying the value by 100.

Informativeness: The ability to convey information is assessed considering measures of informativeness, and thematic units.

Lexical information units (LIUs) are those content or function words that are not only phonologically well-formed, but also used appropriately from a grammatical and pragmatic point of view. Given this definition, semantic and verbal paraphasias, fillers, repetitions, paragrammatic errors, words with ambiguous referent, words that form a tangential utterance or a conceptually incongruent utterance are not considered as LIUs. Percentage of lexical informativeness is calculated by dividing the amount of LIUs by the number of words, and then multiplying it by 100. This percentage provides information about level of communicative effectiveness of the narrative production. Moreover, an index of informative speech rate (LIUs/minute) can add more information about informative efficiency. Information contents can be further investigated considering thematic units. Each picture can be analysed considering elements (essential and detailed) and actions (essential and detailed), the former can be judged as complete and accurate, complete but inaccurate, or absent, whereas the latter as complete and accurate, complete but inaccurate, incomplete or absent. A percentage of thematic selection can be derived by dividing the number of thematic units elicited by the total number of possible units of the story, and then multiplying it by 100. For example about elements and action about the Flower Pot see Table 3.1.

Essential elements	Essential actions
Man	Flower pot falls on man's head
Flower pot	The man gets angry
Dog	The man enters the building / The man is going upstairs
Woman	The man is knocking the door
	The woman opens the door (inference)
	The woman strokes the dog / The woman gives the dog a bone
	The man kisses the woman's hand / They are reconciling
Detailed elements	**Detailed actions**
Balcony	The man is walking
Walking stick	The woman is nice / The woman is smiling
Bone	The man is surprised / The man changes his mind (inference)
Hat	The man raises his hat / The man greets the woman
Door	There is a bump on man's head
Stairs	The dog leaves with the bone / The dog is happy

Table 3.1 – Thematic analysis about "Flower Pot" picture.

3.3.3 – Cognitive tasks and Cognitive Failures Questionnaire

The experiments presented in this Chapter and in Chapter 2 are part of a wider research that involved the same participants attempting to preliminary investigate the cognitive characterization of MW mental states (previously described in Chapter 2), and subsequently to explore the cognitive aspects of communicative effectiveness in different wandering minds. Thus, statistical analysis will refer even to the cognitive tasks previously described in Chapter 2. Specifically, the tasks considered were Digit backward, Listening Span Task, Phonemic fluency, Stroop Test, that were presented orally, Trail Making Test, that was a paper-and-pencil version task, the Attention Network Test (ANT) and the Sustained Attention to Response Task (SART), that were presented on a laptop, and the Cognitive Failures Questionnaire (see Chapter 2 for details).

3.4 – Results

The analyses were carried out through the following steps: at first, we performed a series of correlation analyses in order to guide the choice of narrative variables to include in the PCA. We then performed the Principal Component Analysis (PCA) to reduce the number of variables and to identify a factor underlying narrative scores; the relation between SART indices and narrative factors was then explored by using correlation analyses; finally, the possibility to identify a factor representative of a general tendency to lose the track of the task at hand was explored by using an additional PCA.

3.4.1 – Narrative abilities

Table 3.2 shows descriptive statistics for narrative measures. All narrative measures presented acceptable values of skewness and kurtosis (i.e., skewness < 2; kurtosis < 4) (Kline, 1998), with the exception of % Filler utterances. Thus, two extreme scores have been eliminated from the analysis of this variable making the data approximately normally distributed.

	Range	M (SD)	Skewness	Kurtosis
MLU	3.53 – 12.14	7.58 (1.61)	.390	.830
% Complete sentences	41.96 – 95.45	69.78 (11.87)	-.209	-.409
% Complex sentences	9.37 – 68.75	33.45 (12.66)	.667	.504
% Cohesive errors	2.5 – 51.22	19.88 (9.27)	.648	1.185
% Errors of local coherence	0 – 39.28	10.04 (7.14)	1.250	3.384
% Errors of global coherence	0 – 42.94	14.01 (10.98)	.758	.203
% Filler Utterances	0 – 27.22	5.75 (5.33)	1.257	2.888
% Repeated Utterances	0 – 12.22	2.71 (3.34)	1.066	.113
% Conceptually Incongruent Utterances	0 – 25.97	3.93 (6.02)	1.959	3.641
% Thematic selection	38.46 – 100	68.16 (14.53)	-.011	-.440
Comunicative Fluency	45.25 – 150.35	98.87 (20.39)	-.077	.222

Table 3.2 – Descriptive statistics for narrative measures.

A preliminary correlational analysis was run in order to explore which narrative variables could be inserted in a PCA as an attempt to delineate a factor of communicative effectiveness. As shown in Table 3.3, MLU was highly correlated with % Complex sentences ($r = .656$, $p < .001$), whereas % Cohesive errors was negatively correlated with % of Complete sentences ($r = -.723$, $p < .001$) showing that narratives with longer sentences usually had also a more complex syntactic organization and that the more frequently the sentence was suddenly interrupted the lower was the percentage of complete sentences.

% Errors of global coherence was negatively correlated with MLU ($r = -.331$, $p = .007$), with % Complete sentences ($r = -. 301$, $p = .015$), and with % Complex sentences ($r -.262$, $p = .035$). Not surprisingly, % Errors of global coherence was highly correlated with % Filler utterances ($r = .650$, $p < .001$), % Repeated utterances ($r = .529$, $p < .001$), % Conceptually incongruent utterances ($r =.546$, $p < .001$), and with % Communicative fluency ($r = -.432$, $p < .001$). Additionally, it has been considered how the different types of errors of global coherence (i.e., filler utterances, repeated utterances, conceptually incongruent utterances) was correlated with other narrative measures. Firstly, % Filler utterances correlated negatively with % Complete sentences ($r = -.309$, $p = .014$), and positively with % Repeated utterances ($r = .301$, $p = .017$). Secondly, it has been observed that % Repeated utterances was negatively correlated with % Complete sentences ($r = -.356$, $p = .004$), and with % Errors of local coherence ($r = -.281$, $p = .024$). Thirdly, % Conceptually incongruent utterances was negatively correlated with % Thematic selection ($r = -.450$, $p < .001$), and with Communicative fluency ($r = -.314$, $p = .011$). Finally, % Thematic selection was significantly correlated with Communicative fluency ($r = .349$, $p = .004$), and Communicative fluency was correlated with MLU (r = .424, p < .001), % Complete sentences (r = .500 p < .001), % Complex sentences (r = .282, p = .023), and % Cohesive errors (r = -.303, p = .014).

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
1. MLU	-										
2. % Complete sentences	.228	-									
3. % Complex sentences	**.656*****	.040	-								
4. % Cohesive Errors	-.081	**-.723*****	,011	-							
5. % Errors of local coherence	.065	-.014	.100	-.152	-						
6. % Errors of global coherence	**-.331****	**-.301***	**-.262***	.135	.086	-					
7. % Filler utterances	-.234	**-.309***	-.132	.126	.004	**.650*****	-				
8. % Repeated utterances	-.179	**-.356****	-.071	.202	**-.281***	**.529*****	**.301***	-			
9. % Conceptually Incongruent Utterances	-.237	.070	-.233	-.095	.210	**.546*****	.085	-.025	-		
10. % Thematic selection	**.358****	-.120	,233	,139	**-,285***	-,157	.010	.108	**-.450*****	-	
11. Communicative Fluency	**.424*****	**.500*****	**.282***	**-.303***	-.238	**-.432*****	-.242	-.156	**-.314***	**.349****	-

Table 3.3 – Correlation among narrative measures . * p < .05 ** p < . 01 *** p < .001.

Because of the extremely high correlations among MLU and % Complex sentences, and among % Cohesive errors and % Complete sentences, only MLU and % Cohesive errors were selected for inclusion in the PCA. Furthermore, because of their peculiar differences, the errors of global coherence (i.e., % Filler utterances, % Repeated utterances, and % Conceptually incongruent utterances) were entered separately in the analysis. Therefore, the following narrative measures were entered in the PCA: MLU,

% Cohesive errors, % Errors of local coherence, % Filler utterances, % Repeated utterances, % Conceptually incongruent utterances, % Communicative fluency, and % Thematic selection. Preliminary analyses suggested that the data were suitable for the PCA (the Kaiser-Meyer-Oklin value was (.626), exceeding the value commonly recommended [Kaiser, 1970, 1974], and the Bartlett's Test of Sphericity [Bartlett, 1954] was significant). The PCA revealed the presence of two components with eigenvalues higher than 1, and the scree test suggested to explore up to 2-components solution. The 2-components solution accounted for 50.57% of the variance. This solution yielded, after Varimax rotation, a first component, labelled Communicative effectiveness (28.09% of the accounted variance), including % Thematic selection, % Conceptually incongruent utterances, Communicative fluency, MLU. The second component, labelled Effects of discourse flow interruption (22.48% of the accounted variance), included % Repeated utterances, % Cohesive errors, % Filler utterances and % Errors of Local Coherence (see Table 3.4). The component labelled Communicative effectiveness included narrative variables such as communicative fluency, thematic selection, conceptually incongruent utterances, and MLU. These might explain the ability to be effective and informative from a communicative point of view. On the other hand, the component labelled Effects of discourse flow interruption included % Cohesive errors, % Filler utterances, and % Repetitive utterances, and % Errors of Local coherence. This component might represent possible consequences of a sudden interruption of the discourse flow also considering that almost all cohesive errors were represented by aposiopeses. In other words, it might mean that after an abrupt interruption of the sentence the participants repeated the same words, or filled their sentences with comments or considerations.

Component Transformation Matrix		
	Component	
	1	2
% Thematic selection	**.793**	.174
% Conceptually incongruent utterances	**-.707**	-.077
Communicative fluency	**.703**	-.369
MLU	**.582**	-.415
% Repeated utterances	.053	**.733**
% Cohesive errors	.040	**.593**
%Filler utterances	-.216	**.560**
% Errors of local coherence	-.483	**-.501**

Table 3.4 – The two-factor solution after Varimax rotation. Factor 1: Communicative effectiveness, Factor 2: Effect of discourse flow interruption.

The relation between these two components and the cognitive components described in Chapter 2 was explored highlighting that Communicative effectiveness was positively correlated with Executive Functioning (r = .289; p = .023) (see Table 3.5).

	Executive Functioning	Ineffectiveness of attentional executive control	Alerting
Communicative effectiveness	**.289***	.117	.050
Effects of discourse flow interruption	.109	-.140	.134

Table 3.5 – Correlations among narrative components and cognitive measures. * p < .05.

3.4.2 – Tendency across different contexts

A further step in the analysis was to assess whether the ability to stay on task during an attention task and the ability to communicate effectively are somehow related. As mentioned above, the SART is sensitive to MW frequency as MW affects the reaction times (RTs) to SART stimuli. Specifically, as highlighted in Chapters 1 previous studies have found a difference between reaction times that precede an error and those that precede a correct no-go response. This leads to a variability of reaction times (RTCV) that has been shown to correlate with states of MW. As such, the RTCV might reflect the ability to stay on task or conversely the tendency to generate states of MW. In the current study, Communicative effectiveness was negatively correlated to the RTCV ($r = -.323$; $p = .010$). This result suggests a possible tendency to lose the track of the task at hand across different tasks. After that, as a last step in the analysis, it was explored whether it was possible to identify a general factor of loss of track at hand. To do this, a PCA was performed on a set of 6 variables, namely RTCV, Communicative effectiveness, CFQ, Executive Functioning, % Aware of MW, and % Unaware of MW. The selection of only % Aware of MW and % Unaware of MW was driven by the results that showed a significant role of executive resources in explaining their occurrences. The Kaiser-Meyer-Oklin value was (.534), and the Bartlett's Test of Sphericity (Bartlett, 1954) was statistically significant. The PCA revealed the presence of two components with eigenvalues higher than 1, and also the scree test suggested to explore up to 2-component solution. The 2-components solution accounted for 52.33% of the variance and yielded, after Varimax rotation, a first component (28.18% of the accounted variance), including Communicative effectiveness, Executive Functioning, and % Unaware of MW, whereas the second component (24.15% of the accounted variance), included RTCV, % Aware of MW, and CFQ (see Table 3.6). The rotated solution showed that SART can be considered not only as a reliable task to explore MW tendency in laboratory, but also it seemed to mirror a trend in everyday life as self-reported by participants in the CFQ. Communicative effectiveness did not load on the same factor as RTCV and CFQ, however it is interesting to note that the ability to produce a narrative appropriate from a communicative point of view shared variance with % Unaware of MW with a negative association. Moreover, the presence of Executive Functioning in the component may indicate that a high amount of resources is necessary to organize an informative narrative production and to prevent loss of meta-awareness while performing an activity.

Component Transformation Matrix

	Component	
	1	2
Communicative effectiveness	**.744**	-.013
Executive Functioning	**.602**	-.384
% Unaware of MW	**-.590**	-.024
RTCV	-.322	**.724**
% Aware of MW	.568	**.643**
CFQ	.028	**.603**

Table 3.6 – The two-factor solution after Varimax rotation

3.5 – Discussion

This study aimed at investigating whether there was a general trend to lose the track of what it is doing by considering different contexts, such as a sustained attention laboratory task, a narrative discourse production, and everyday life activities as measured by the CFQ.

As a preliminary phase, a correlation analysis supported the choice about which narrative variables should be analysed deeper by performing a PCA in order to attempt the identification of a factor that would convey information about communicativeness.

Communicativeness may be achieved through a discourse production characterized by relevant information without any grammatical or pragmatic errors such as the production of words with no clear referents, repetitions, fillers, or conceptual errors. The PCA allowed to identify a component that provided information about the participants' ability to communicate through narrative discourse. The Communicative efficiency component included % Thematic selection, % Conceptually incongruent utterances, Communicative fluency, and MLU. It seemed that communicative efficiency might be explained by longer utterances, which implies utterances grammatically more complex that can help in conveying message more effectively. In addition, it was highlighted that efficiency was greater as more thematic units were mentioned and as individuals were more able to select fluently correct words from all points of view. As last, the levels of communicative efficiency depended on the presence of correct information and absence of conceptually incongruent meanings compared to the picture that participants saw. Our findings confirm the possible role of executive functioning during the process of narrative production (see also Marini et al., 2014; Mozeiko et al., 2011): higher levels of communicative efficiency were associated to better executive resources. In other words, more available resources may allow a better control during discourse production. Such control may take place starting from the first step of the perceptual stimulus analysis, and then continuing through the organization of information into episodes that will be translated into words, sentences and global discourse.

Another research line of interest for this study is the one involving the relationship between executive resources and MW (Smallwood & Schooler, 2006). Executive resources play a major role in producing a narrative discourse appropriate from a communicative point of view, and also in MW occurrences. Given that, it was explored whether the ability to produce an informative narrative discourse and the ability to stay on task during a sustained attention task are somehow related and could be explained by an executive underpinning. Moreover, this study investigated whether the ability to convey information appropriate from a pragmatic point of view could be considered as representative of well-directed attention, and whether a factor of general ability/inability to stay on task might be identified. Results showed that the RTCV, a behavioural index derived from SART, was significantly correlated with Communicative effectiveness. As previously described, RTCV was shown to vary depending on the ability to remain focused on the task. Thus, the association between this index and Communicative effectiveness may suggest that losing the track of what it is being done might be considered as a tendency across different tasks. Further analyses allowed us to support this claim. A PCA was performed to explore whether it was possible to isolate an index of derailment from the purpose of what it is being done (in this specific case a sustained attention task, a production of a goal-directed message, and everyday activities) and the possible role of executive functioning in explaining it. Results did not confirm the initial hypothesis; indeed, two components were extracted. On the one hand, the first component included Communicative efficiency, Executive functioning, and % Unaware of MW, on the other hand the second component included RTCV, % Aware of MW, and CFQ. The first one revealed an underlying connection between communicativeness, executive resources, and lacking of awareness of contents of mind. This suggests that those individuals who provided the most efficient narrative sample were the same who reported with lower frequency to be unaware of MW, and that the Executive Functioning may play a role in controlling these occurrences. Communicativeness results from complex processes that proceed through several steps, thus the more the individual is present in the here and now, the more communicative the message could be. A brief mention should concern the unclear loading of % Aware of MW; indeed this variable loaded almost equally on both components and could provide further support to the suggestion about the need to be present to communicate effectively. About the second component, results of this study showed that CFQ and RTCV shared a same part of variance providing further support to the reliability of the SART, and particularly of the behavioural index of RTCV. Similarly, a study performed by Robertson and colleagues (1997) revealed that variation in SART performance mirrored changes in the score at CFQ demonstrating the sensitivity of this task in reflecting failures due to attentional lapses experienced in daily life.

Finally, a brief mention about possible future directions. As first, more studies are needed about the potential relation between MW and poor communicativeness. This study did not take into consideration experience sampling during the narrative task, thus no direct reports of mental states were available. However, the use of a retrospective sampling method, namely a questionnaire about thoughts experienced during the task, might allow to obtain information about mental experience preserving the continuity of task execution. The other two thoughts samplings, namely the probe-caught and the self-caught method, could not be appropriate given the characteristics of the task. For example, a probe-caught sampling could not be applied due to the difference between individuals in time needed to complete the narrative task, indeed some participants might accomplish the task in just few seconds, whereas others could continue for minutes. As second, the importance of an association between self-reported MW and objective measures is well known. Previous studies have shown that MW determines a narrowing of visual attention during a driving simulated task (He, Becic, Lee & McCarley, 2011), a changing in fixation duration during a reading task (Reichle, Reineberg & Schooler, 2010) and even differences in vocal output between attentive and mindless reading (Franklin, Mooneyham, Baird & Schooler, 2014). A purpose for future studies might be to combine narrative production and eye movement while participants are watching the picture; it might be interesting to explore whether there are differences in eye movement when some errors, such as missing referents or filler utterances, are committed. Moreover, given that narrative task is an oral task, voice volume and changing in intonation might be salient measures. A last consideration is about the type of task used to explore the relation between MW and communicativeness. Limitations of MW investigation during a discourse production have emerged, however a jointly produced narrative task might be more suitable for this purpose, and would allow greater control. A jointly produced task is a more ecological task, indeed in everyday life a story-telling by a single individual is uncommon, rather there is an active cooperation among co-tellers (Jorgensen & Togher, 2009) and turn-taking is necessary. Individuals are not only tellers, but also active listener and have to pay attention to what it is telling in order to continue in a coherent manner. In conclusion, future researches should be oriented to study how MW affects a conversation, intended as including both discourse comprehension and production, rather than only taking into consideration production processes. Indeed, given the alternation between listener and speaker role, it could be investigated how MW affects both comprehension and production by using probe caught during comprehension phase, and retrospective method during speaker one.

Chapter 4

Mind Wandering in a simulated driving context: An experimental investigation [6]

4.1 – Introduction

Driving is a complex, cognitively demanding, and dynamic activity. It is well known that during a driving task all cognitive resources have to be focused on the task at hand for an attentive driving (Young & Regan, 2007). Any secondary activity, often engaged by drivers behind the wheel, such as using a mobile phone (e.g., Drews, Pasupathi & Strayer, 2008; Horrey & Wickens, 2006; Strayer & Drews, 2004; Strayer, Drews & Johnston, 2003; Strayer & Drews, 2007), interacting with in-vehicle devices (Lee, Caven, Haake & Brown, 2001), or conversing with passengers (e.g., Drews et al., 2008; Lansdown & Stephens, 2013; Strayer & Drews, 2007) may compete for the limited processing resources with a negative consequence on the primary driving task. For instance, drivers who are engaged in a mobile phone conversation are significantly slower to react to traffic signals (Strayer & Johnston, 2001; Strayer et al., 2003) and to depress brake pedal (Consiglio, Driscoll, Witte & Berg, 2003), are more likely to miss simulated traffic signals (Strayer & Johnston, 2001) and to fail recognizing previously gazed objects due to the deviation of attentional resources from the driving environment

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to conversational context (Strayer & Drews 2007; Strayer et al., 2003). It has also been shown that the higher the emotional valence of a conversation, the larger is its detrimental effect on driving performance (e.g., Briggs, Hole & Land, 2011; Dula, Martin, Fox & Leonard, 2011). Moreover, conversing with a passenger may decrease driving performances to a lesser extent than what a cell-phone conversation does because of a conversation modulation that may consist, for instance, of alerting comments, of warning of hazards, and of conversation suppression (Charlton, 2009), of a reduction in the complexity of speech production (Drews et al., 2008), and of an conversational adaptation to driving demands (Strayer & Drews, 2007). Even a speech-based interaction with in-vehicle computers may lead to slower reaction time to critical events (Lee et al., 2001). Generally speaking, the level of distraction that a secondary task exerts on driving performance may depend on several factors, such as driving demands (e.g., familiarity of the road, traffic condition), complexity of the secondary task (e.g., emotionality of the conversation), and driving experience (Young & Regan, 2007).

It is well known that not all lapses of attention arise from secondary tasks. Indeed, distraction may also be caused by *mind wandering* (MW; Smallwood & Schooler, 2006). Several lines of research (see Chapter 1) showed that MW has a costly influence on many cognitive processes, such as reading comprehension, sustained attention and encoding (e.g. Hu, He & Xu, 2012; Christoff, Gordon, Smallwood, Smith & Schooler, 2009; Schooler, Reichle & Halpern, 2004; Smallwood, O'Connor, Sudberry, Haskell & Ballantyne, 2004). Little is yet known, however, about the effects of MW on driving performance. An epidemiological study by Galéra and colleagues (2012) highlighted that drivers who reported intense MW before having a car crash were significantly more likely to be responsible for the accident, providing a first connection between the phenomenon of MW and car crash risk. To date, only two studies experimentally assessed on-line driving performance consequences of MW using a driving simulator (He, Becic, Lee & McCarley, 2011; Yanko & Spalek, 2014). He et al. (2011) used a car-following task where drivers had to maintain a safe headway distance while following a lead car that drove at an average speed of 45 mph, and to keep ahead of a trailing car. Similarly, in Yanko and Spalek's (2014) study, drivers were asked to follow a pace car, which varied the distance from the participant's vehicle. In both studies, the pace car was programmed to brake at randomly selected times throughout the route. He et al. (2011) and Yanko and Spalek (2014) detected MW episodes using a self-caught and a probe-caught sampling procedure, respectively (Smallwood & Schooler, 2006; see Chapter 1). He and colleagues (2011) compared measures of vehicle control and oculomotor behaviour during and after episodes of MW episodes. Their major finding was that MW states lead to a narrowing of visual attention, as indicated by drivers gazing less at their side mirrors and by a reduction of the horizontal deviation of gaze position. Vehicle control appeared, however, quite robust to MW even though standard deviation of speed was slightly lower during mindless driving than during attentive driving. Yanko and Spalek (2014) measured braking RTs, velocity, and headway distance during MW states and attentive driving over the 10 seconds before probe presentation. They observed that when participants experienced MW episodes, they were slower in pressing the brake pedal, were going at a higher speed, and kept a less safe distance from the ahead vehicle.

4.2 – Aims of the study

Despite its apparent ubiquity in daily life (e.g., Killingsworth & Gilbert, 2010), research on the effect of MW on driving performances is still in its infancy, perhaps due to the inherent difficulty in directly measuring such a subjective phenomenon. The aim of the present study is to further investigate on this issue and, at the same time, to assess (1) the effect of MW on basic driving skills, and (2) whether the effect of MW on driving behaviour varies according to whether the probe-caught or the self-caught sampling procedure is used. The probe-caught methodology implies that a thought probe is presented at random interval and participants have to define their mental state at the moment just before the probe presentation accordingly to the definitions provided before the beginning of the task. The self-caught methodology requires participants to report by themselves every time they become aware of being off-task.

As the first issue is concerned, in the present Study a lane-keeping task was used rather than a car-following task, as in He and colleagues (2011) and in Yanko and Spalek (2014). Although a car-following task shapes more closely real driving behavior, it requires overall more processing resources given the presence of the leading vehicle that can be considered as an additional variable, as compared to the relatively automatic and basic driving skills of lane-keeping task that assess only lateral lane position and speed maintenance, and may therefore be less likely to encourage MW (Kane et al., 2007; Kane & McVay, 2012). With respect to the second issue, although the probe-caught and the self-caught sampling methodologies are both valid ways of assessing MW (Smallwood & Schooler, 2006; 2015), the difference between these methodologies is critical within the context of driving performances. Indeed, the probe-caught sampling allows to detect MW states that occur both with and without explicit awareness, whereas the self-caught sampling allows to detect only the MW states occurring with explicit awareness (Smallwood & Schooler, 2006). Converging results of on-road and simulator studies show that drivers do not passively endure distraction arising from secondary activity but they rather attempt to reduce risk exposure by adopting self-regulatory behaviours, such as by decreasing speed (e.g., Chiang, Brooks & Weir, 2001; Haigney, Taylor & Westerman, 2000; Horberry, Anderson, Regan, Triggs & Brown, 2006; Young & Regan, 2007) and by increasing inter-vehicle distance (e.g., Jamson, Westerman, Hockey & Carsten, 2004; Strayer & Drews, 2004; Strayer et al., 2003). Likewise, participants may adopt compensatory behaviours when they experience MW states, while such behaviours are unlikely to occur when participants are not aware of being distracted by MW. It may be therefore useful to disentangle between these two conditions when assessing the effect of MW on driving performances. Yanko and Spalek (2014) and He and colleagues (2011) used the probe-caught and the self-caught sampling methodology, respectively. Although their results converge in showing that MW is a source of distraction able to impact on driving performances, in Yanko and Spalek (2014), after probe presentation, drivers had only to refer whether or not their mind had been wandering just prior the probe presentation without any distinction between level of awareness.

4.3 –Methods

4.3.1 – Participants

Thirty-one drivers participated in the present Study. They were randomly assigned to two experimental groups, namely 17 to the Probe-Caught (8 female; age, M = 22.29, SD = 2.89) and 14 to the Self-Caught group (10 female; age, M = 26.07, SD = 3.41). All drivers had no history of neurological or psychiatric disorders, and they all had normal or corrected-to-normal vision.

4.3.2 – Material

Data were collected in a high-fidelity simulator (Figure 4.1), composed by a 22 inch screen LCD TFT WIDESCREEN FULL HD (providing a more realistic and extended vision), wheels and pedals Thrustmaster T500RS 1:1 (for a more realistic driving), and gear Thrustmaster TH8RS. The software used to create the driving environment was the Racer 0.8.34. The driving task consisted in a lane-keeping task, lasting 20 minutes. The driving environment comprised a straight road with no cars and meadows on the roadside that intentionally made the task dull and monotonous in order to favour MW arising. The aims of the task were to maintain the trajectory into the lane and to observe the speed limit of 130 km/h.

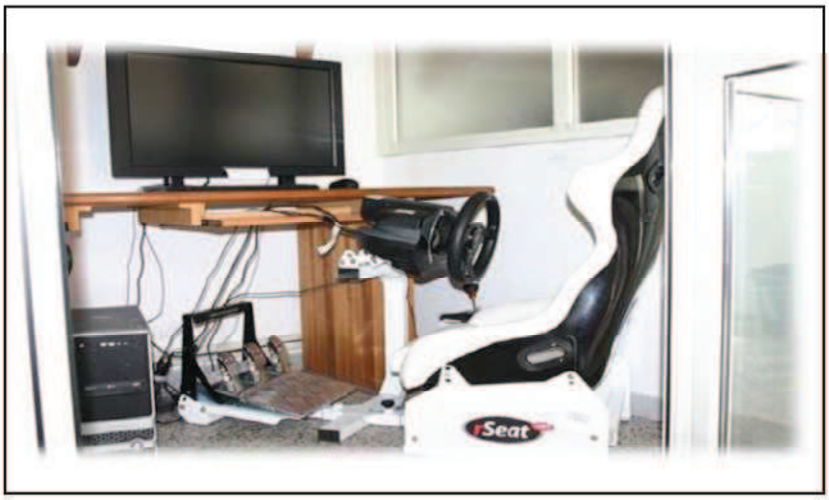

Figure 4.1 - The driving simulator

4.3.3 – Procedure

Participants in the probe-caught group were presented with 4 probes at irregular intervals during the lane-keeping task. We decided to use a small number of probes as Seli, Carriere, Levene and Smilek (2013) noticed that the frequency of MW states increases with larger time intervals between probes. Accordingly, the probe consisted of darkening the computer screen. The first and second probes were presented between the 3rd and the 5th minute, and between the 7th and the 9th minute, respectively; the third and fourth probes were presented between the 13th and the 15th minute, and between the 17th and the 19th minute respectively. This probes distribution aimed at ensuring that two probes would occur within the first half, and the other two probes would occur within the second half of the driving session. Before starting the driving task, participants were given the definition and examples of MW. MW was defined as thinking about something unrelated to the driving task at hand, and some examples were provided (e.g., planning future events, remembering past events, daydreaming). Next, they were given definitions to use in order to classify their mental state at the moment of probe presentation, i.e., on task, aware of MW, unaware of MW. Participants in the Self-Caught group were given the definition and examples of MW, as in the Probe-Caught condition, and were instructed to press a button at the back of the steering wheel any time they found themselves wandering.

4.3.4 – Dependent variables

Vehicle speed and vehicle stability were recorded. Speed was measured as the average speed in Km/h (M-SPEED), and as the standard deviation of speed (SD-SPEED) that provided information about speed maintenance during the task, whereas stability of the vehicle was measured as the standard deviation of the lateral position (SD-LP), indicating the variability of motion of the car along the lane, and as the standard deviation of the steer (SD-STEER), indicating the variability of the angle of steering. Speed and vehicle stability indices were recorded over a 10 seconds period prior to probe presentation (Yanko & Spalek, 2014), in the Probe-Caught group, or prior to button pressing, in the Self-Catch group (now onward this time interval will be referred to as *MW mental state*), and from 10 to 20 seconds after probe presentation or button pressing (now onward this time interval will be referred to as *Full attention mental state*). The study performed by He and colleagues (2011) considered the period from 20 to 29 seconds after the mental state report as attentive interval. However, in our opinion this interval considered a period of time too far from the moment when mental state was reported and this could potentially result in a contamination by other MW mental states.

4.3.5 - Statistical analyses

One participant in the Probe-Caught group was excluded from the analyses because he/she did not reported any MW episode. In the Self-Caught condition, those episodes of MW occurring at less than 30 seconds from each other were excluded from the analyses as the relevant time interval of full attention was assumed to occur from 10 to 20 seconds after button press (see §§ 4.3.4).

For each participant in each group means scores for each dependent variable were calculated as a function of mental state. Two sets of analyses were conducted. First, the frequency of MW states was assessed. Second, each dependent variable was analysed by a 2 (Mental state: MW vs. Full attention) x 2 (Group: Probe-Caught vs. Self-Caught) ANOVA in order to explore whether MW affects driving behaviour and whether its effect differs according to whether the probe-caught or the self-caught sampling procedure is used. For this analysis only aware wanderings reported by participants in the Probe-Caught group were taken into consideration in order to compare them to MW episodes reported by participants in the Self-Caught group.

A third set of analysis intended to compare different level of awareness (i.e., aware vs. unaware) of MW episodes experienced by participants in the Probe-Caught group. It is well known that during secondary tasks drivers adopt self-regulatory behaviours for limiting costs on performance (Alm & Nilsson, 1994; Haigney et al., 2000). The compensatory strategies are likely to be engaged because drivers are aware that they are performing a secondary task. Given that, it may be worthwhile disentangling between the effects of MW states occurring with and without explicit awareness on driving performance. Unfortunately, in the present study, only one episode of MW without awareness was referred, preventing any further comparison. Since this participant referred to be on task at the other probes presentation, he/she was excluded from further analysis.

4.4 – Results

Frequency of MW states. On average, participants in the Probe-Caught group reported 2.13 MW episodes (SD = 0.99), corresponding to 53.3% of thought probes. It is interesting to note that number of MW episodes increased over time; indeed, 33.3% , 40%, 80% and 60% of the participants reported a MW state when the first, the second, the third and the forth probe was presented, respectively. On average, participants in the Self-Catch group reported 9.29 (SD = 2.73) MW episodes. By sectioning the driving task into 4 parts of 5 minutes each, an increment of the number of MW episodes over time was highlighted; indeed, on average, 1.86, 2.43, 2.36, and 2.64 MW episodes were reported in the first, second, third and fourth part of the driving task by participants in the Self-Caught group.

Effects of MW and of sampling procedure on driving performance. The mean (and standard deviations) of measures of speed (M-SPEED, SD SPEED) and of vehicle stability (SD-STEER, SD-LP) are presented in Table 4.1 as a function of mental state. As long as M-SPEED is concerned, results showed only a main effect of Group, $F(1,27) = 6.883$ $\eta p^2 = .203$ $p = .014$, indicating that participants in the Self-Caught group drove overall faster as compared to participants in the Probe-Catch group. With respect to SD-SPEED, results showed a significant main effect of Mental state, $F(1,27) = 10.783$ $\eta p^2 = .285$ $p = .003$, indicating that SD-SPEED was lower during MW than during full attention. The Mental state x Group interaction was also significant, $F(1,27) = 10.021$ $\eta p^2 = .271$ $p = .004$; indeed, the difference between MW and Full attention was significant for Probe-Caught Group, $t(14) = -3.610$ $p = .003$, while it was not significant for Self-Caught Group, $t(13) = -.151$ $p = .882$. Concerning the vehicle stability indices, results showed that the Mental state x Group interaction for SD-STEER approached significance, $F(1,27) = 4.161$ $\eta p^2 = .134$ $p = .051$, showing that participants in the Probe-Caught group had a more stable steer control during MW states than during attentive driving, whereas participants in the Self-Caught group had less stable steer control during MW states than during attentive driving. However, the difference was neither significant for Probe-Caught Group, $t(14) = -1.421$ $p = .177$, nor for the Self-Caught Group, $t(13) = 1.457$ $p = .169$. Results concerning SD-LP did not show any significant effect.

	Mind Wandering		Attention	
	Probe-Caught Group	Self-Caught Group	Probe-Caught Group	Self-Caught Group
M-SPEED	104.07 (17.27)	119.32 (16.38)	100.59 (18.22)	117.34 (15.56)
SD-SPEED	1.43 (0.70)	2.09 (0.84)	2.77 (1.64)	2.12 (0.97)
SD-STEER	0.88 (0.42)	1.28 (0.76)	1.07 (0.63)	1,07 (0.45)
SD-LP	14.71 (3.92)	15.99 (5.69)	12.68 (5.53)	16.85 (4.87)

Table 4.1 – Means (and standard deviations) of measures of speed (M-SPEED, SD SPEED) and vehicle stability (SD-STEER, SD-LP)

4.5 – Discussion

The main purposes of this study were to explore the effect of MW on basic driving skills, and to assess whether the effect of MW on driving behaviour varies according to whether the Probe-Caught or the Self-Caught sampling procedure is used.

MW episodes were detected by both sampling procedures. The two sampling procedures used (i.e., probe-caught sampling and self-caught sampling) highlighted that the two methodologies provided different information about the moment in which the mental state is defined. In other words, the probe-caught sampling implies a probe presentation that is not necessarily presented at the exact moment in which the attention drifted away from the task, whereas the self-caught sampling relies on the participants' declaration of their mental state as soon as they notice a MW state. According to these considerations, it seems plausible to assume that when the probe-caught sampling procedure is used, some time is likely to elapse from when the drivers become aware of MW and the moment in which the probe is presented, thus compensatory behaviours can be endorsed. Conversely, in case the probe presentation catches a MW state characterized by lacking of awareness, direct consequences of MW on performance can be observed. Similarly, the self-caught procedure could provide information about the direct effect of MW on the performance of task at hand. In line with these considerations, these two thoughts sampling methodologies might be used depending on the different aspects that would be investigated.

Our results showed that the frequency of MW episodes increased with time on task in both the Probe-Caught and the Self-Caught condition. This result is in line with findings of earlier studies on MW during attentional (McVay & Kane, 2009) and encoding tasks (Smallwood, Riby, Heim & Davies, 2006; Smallwood, Obonsawin & Heim, 2003) and may be likely accounted for within the decoupling hypothesis (Smallwood & Schooler, 2006; see Chapter 1). This hypothesis suggests that, during MW episodes, executive resources are directed away from the primary task in order to allow the flow of thoughts. Accordingly, MW is more likely to occur when the task at hand is automatic, and does not rely on executive control, than when it is more demanding. The progressive automatization that occurs over time (Schneider & Shiffrin, 1977) of the processes involved in simulated driving is therefore likely to have disengaged executive resources which are therefore available for MW. About this study, it should be remembered that in the Probe-Caught condition only MW episodes characterized by awareness were taken into consideration because only one episode of MW without awareness was referred, preventing any further comparison.

The effect of MW on driving behaviour was assessed by comparing driving performances, as indexed by M-SPEED, SD-SPEED, SD-LP, and SD-STEER, recorded during MW and during full attention. Overall, participants in the Probe-Caught group drove slower than participants in the Self-Caught group. As mentioned previously, this difference in driving speed may likely be an intrinsic consequence of the methodological difference between the sampling procedures. The Probe-Caught procedure requires participants to stop driving to report their mental states, while the Self-Caught procedure does not interrupt the driving task. It is therefore not surprising that participants in the Self-Caught group could reach a higher driving speed than participants in the Probe-Caught group, who had to stop at each probe presentation. Results showed that the effect of MW on driving behaviour varied according to the sampling procedure used. Indeed, speed maintenance of participants in the Probe-Caught group was better, as indexed by significantly smaller SD-SPEED, during MW than during full attention. Differently, participants in the Self-Caught group showed equivalent speed maintenance during MW and during full attention. Results also spotted a trend for a differential effect of probe-caught and self-caught sampling on steer maintenance, although the differences appeared not statistically significant, probably due to the small number of participants. Steer maintenance of participants in the Probe-Caught group was marginally better, as indexed by smaller SD-STEER, and marginally worst, as indexed by larger SD-STEER, during MW than during full attention for participants in the Probe-Caught and for participant in the Self-Caught group, respectively. The different patter of results obtained using self-caught and the probe-caught sampling procedure may be likely attributed to unintentional and intentional consequences of MW. He and colleagues (2011) suggested that, when the self-caught sampling procedure is used, differences in driving behaviour during MW episodes and during full attention may be the inherent consequence of distraction. Indeed, drivers report MW episodes immediately after becoming conscious of them, before implementing any strategic behaviour changes. However, when the probe-caught sampling procedure is used, some time is likely to elapse from when the drivers become aware of MW and the presentation of a probe, and compensatory behaviours can be endorsed. Based on these considerations our results therefore suggest that basic driving skills, i.e., vehicle speed and vehicle stability, are robust to MW, as indicated by equivalent M-SPEED, SD-SPEED, SD-LP, and SD-STEER during MW episodes and full attention in the Self-Caught group. The reduced SD-SPEED (and eventually of SD-STEER) during MW than during full attention, observed in the Probe-Caught group, may instead reflect strategic responses to distraction.

In conclusion, this study further highlighted the differences between the two thought sampling methodologies (i.e., probe-caught sampling, and self-caught sampling). On the one hand, it was shown that the probe-caught method might be also used in order to assess how the participants compensate their performance. Indeed, the probe-caught method might provide information about participants' behaviour after having become aware of their MW mental states. On the other hand, the self-caught method allows to investigate how behaviour changes in the moment just before becoming aware of a MW mental state providing information about the direct effect of MW on task performance. Moreover, the results of this study suggest that inattention deriving from MW does not significantly affect the basic driving skills involved in the lane-keeping task, and draw attention on the critical implications that the use of probe-caught and self-caught sampling procedure has in the context of the study of MW effect on driving performances. The self-caught procedure may indeed be more suitable for studying the detrimental effect of MW on driving performances, whereas the probe-caught procedure can inform on the nature of the strategic responses to distraction derived from MW.

Chapter 5

Mind wandering in everyday driving context. A questionnaire investigation[7]

5.1 – Introduction

Several lines of research showed that *mind wandering* (MW; Smallwood & Schooler, 2006) has a costly influence on many cognitive processes such as attention, reading comprehension and encoding (see Chapter 1). Only recently attention has been directed on assessing the effect of MW on driving performance. As discussed in Chapter 4, only two studies experimentally assessed the consequences of MW on driving performance by using a car-following task (He, Becic, Lee & McCarley, 2011; Yanko & Spalek, 2014). These studies showed that MW influences driving performance by increasing response times to sudden events, shortening headway distance, and narrowing visual attention on the road ahead. The study presented in Chapter 4 highlighted that MW does not affect basic driving skills, and drew attention to the critical implications of the different thoughts sampling methodologies in the field of MW effect on driving performance. Another way to explore the effect of MW on driving performance is by using an off-line method, namely a questionnaire. Berthié et al. (2015) administered a questionnaire to characterize off-task thoughts with respect to driver personal

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characteristics, context in which MW occurs, awareness of MW episodes and characteristics of the thoughts. They observed that 85.2% of the participants reported having experienced episodes of MW during their last trip. The duration of MW episodes was associated with driver's experience and with driving context. Indeed, the greater the driving experience, as quantified by the number of kilometres driven per week, and the lesser the attention required to drive, such as along familiar commutes, monotonous motorways or by-passes, are, the longer is the duration of MW episodes. The duration of MW episode was however unrelated to demographic variables, such as gender and age, and to other personal characteristics, such as mental workload and level of well-being. The majority of participants who reported to become immediately aware of MW episodes perceived little changes in their driving performance, whereas those who reported to became aware of MW episodes after few minutes observed significant changes. Overall, changes in driving behaviour were described as related to poor vehicle control, as indexed by speed and lateral position. Concerning the contents of MW episodes, Berthié et al. (2015) found that most often they concerned private concerns and were primarily related to the future and to the present; the majority of the thoughts concerning the present or the future had a neutral valence, whereas those related to the past were mostly characterized by a positive contents. Burdett, Charlton and Starkey (2016) explored the influence of environmental contexts, states, such as fatigue or being stress, and personal traits, such as frequency of cognitive failures or mindful attention, on MW frequency during everyday driving. They found that factors such as route familiarity, tiredness, young age, higher proneness to cognitive failures, and lower level of mindful attention increased the frequency of MW during driving. Moreover, they found that the variance of MW behind the wheel was predicted by younger age, lower level of mindful attention in everyday life, more lapses of attention and more violations in driving behaviour.

5.2 – Aims of the study

To our knowledge, the studies of Berthié and colleagues (2015) and Burdett and colleagues (2016) are the only studies that used an off-line method in order to characterize MW behind the wheel. The aim of the present study was to better explore the core features of MW during everyday driving. For instance, we intended to explore (1) which contextual and emotional conditions are more likely to induce MW, (2) the influence of demographic variables on the frequency of MW, (3) the relation between MW and other types of common source of distractions behind the wheel, (4) the contents of MW, (5) the perceived consequences of MW on driving performances, and (6) the perception of risk associated to MW and to other forms of distraction.

5.3 – Materials and methods

5.3.1 – Participants

The questionnaire was presented to 161 Italian drivers (76 male). Mean age and education of the participants were 33.48 years (SD = 13.02; range: 19 – 76 years) and 14.90 years (SD = 2.59; range 8 – 18 years), respectively. All participants obtained their driving license at least one year before filling the questionnaire (M = 14.48 years; SD = 12.45; range: 1 – 45 years).

5.3.2 – Questionnaire

The questionnaire consisted of five sections. The first section concerned demographic information, such as gender, age, years of education, and years of driving licence, and general information about driving habits, such as driving frequency, length of the habitual route, and frequency of passengers on board. The second section concerned MW. Two questions explored frequency of MW while driving. Given the high correlation among these two items ($r = .664$ $p < .001$), and the high reliability, as measured by Cronbach's alpha (.798), a mean score was calculated and a MW Frequency Scale was extracted. Other questions assessed the emotional and physical contexts more frequently associated to MW, the contents of MW, the perceived consequences of MW on driving behaviour. The third section investigated the level of awareness of MW and the ability of monitoring of attention. The fourth section investigated the frequency with which technologies, such as mobile phone or GPS, and in-vehicle devices, such as heat or radio, are used during driving. The fifth section explored risk perception associated to MW and to technologies used during driving. Participants were asked to answer the questions using a 5-point Likert scale (ranging from 0 "never to 4 "very often"), or selecting more than one option. All questions concerned driving behaviour during last year.

5.4 – Results

The analyses were carried out through the following steps: as first, a Principal Component Analysis (PCA) was performed to explore whether it was possible to identify a MW factor that would specify environmental and emotional conditions that might favour MW episodes, and the relation between MW and other types of common source of distractions; as second, a correlation analysis was performed to investigate the relation with demographic variables; as third, a regression analysis was performed to predict which variables could account for MW variance; as last, a brief description of percentage distribution about contents of MW episodes, behavioural consequences of MW episodes, and perception of risk associated to MW and to other forms of distraction was presented.

5.4.1 – Principal Component Analysis

A PCA was performed in order to assess MW and different kinds of distraction (such as use of technologies and interaction with in-vehicle devices) in everyday driving. The PCA was performed on the set of 17 items that considered contexts that might encourage or discourage MW (from section two) and several kinds of distraction (from section four). The first six eigenvalues were 6.42, 1.81, 1.26, 1.05, .96, .83. The scree test suggested to explore up to 4-component solution. Figure 5.1 illustrates the hierarchy of 2 to 4-component solutions, after Varimax rotation.

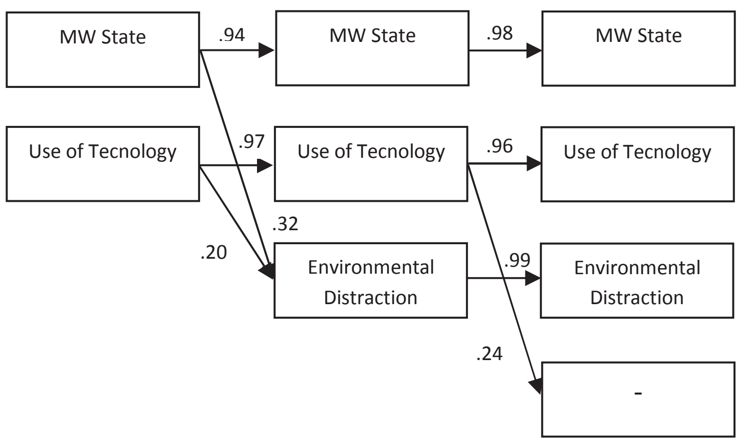

Figure 5.1– Two to four factor solution.

The 2-component solutions yielded a larger component (33.774 percent of accounted variance) labelled MW State and it included conditions such as not much traffic, being alone inside the car, route familiarity, having many concerns, feeling sad. The second component (14.693 percent of accounted variance) was labelled Use of Technology and it included behaviours such as texting messages, talking on the mobile phone, checking GPS, and being unfamiliar with the road. When 3-components were extracted and rotated, the factor solutions showed that the first two components clearly replicated the domains from the 2-component solution (see Figure 5.1) and the third component (accounting for the 11.805 percent of the total variance) included items indicating that environmental cues or conditions trigger the driver's disattention, it was therefore labelled Environmental Distraction. The 3-component solution is presented in Table 5.1. The 4-factor solution robustly replicated the domains emerged from the 3-component solution, with a fourth weak component which included two items only, and was not further considered therefore. To further interpret the relation among these components, Oblimin rotation was performed. The result was similar to that of the Varimax rotation, indeed variables loaded on the same factors as in Varimax rotation. MW State was weakly correlated ($r = .294$) with Use of Technology, and even Use of Technology and Environmental Distraction was weakly correlated ($r = .227$), showing a relatively independency from each other. On the other hand, a slightly higher correlation was shown between MW State and Environmental Distraction ($r = .364$).

How often does it happen:	Components 1	2	3
r. to be distracted by thoughts that are unconnected to driving when you have many concerns?	**.827**	.031	.174
p. to be distracted by thoughts that are unrelated to driving when you are in sad mood?	**.824**	-.028	.166
c. to be distracted by thoughts that are unconnected to driving when you are alone in your car	**.815**	.125	.162
l. to be distracted by thoughts that are not connected to driving during low traffic condition?	**.812**	.128	.198
j. to be distracted by thoughts unconnected to driving when you are familiar with the road?	**.752**	.092	.319
m. to be distracted by thoughts that are unrelated to driving when you drive in urban routes?	**.733**	.196	.051
i. to be distracted by thoughts that are unrelated to driving when you are in happy mood?	**.659**	.134	.348
g. to be distracted by thoughts that are not related to driving when you are driving on the highway	**.596**	.287	.122
e. to be distracted by thoughts that are unrelated to driving during heavy traffic conditions	**.505**	.354	.040
a. to tune the radio while you are driving	**.358**	.037	.041
k. to text message, to mail or to use some application of your mobile phone when you are driving?	.158	**.845**	-.037
d. to talk on the mobile phone while you are driving	.162	**.831**	.020
h. to check or set the road to take on the navigator when you are driving	.047	**.575**	.338
o. to be distracted by thoughts that are not connected to driving when you are unfamiliar with the road?	.053	**.434**	.129
f. that thoughts that are not connected to driving are triggered by environmental stimuli (music, shops, billboards etc.)	.224	.051	**.802**
n. to set air conditioning or heating inside the car when you are driving?	.133	.083	**.668**
q. to be distracted by external stimuli (for example: look at shops, at people that are walking on the sidewalk, at the landscape etc..) while you are driving?	.308	.268	**.645**

Table 5.1 - The three-factor solution after Varimax rotation.

Component scores from the 3-dimension solution were correlated with the short MW Frequency Scale. Simple correlations showed that the MW Frequency Scale was highly correlated with MW State domain ($r = .75$, $p < .001$), and weakly correlated with Environmental Distraction ($r = .163$ $p = .039$), whereas Use of Technology ($r = .111$ $p = .161$) did not correlate. In addition, simple correlations between MW Frequency Scale and each single item presented in Table 5.1 that loads on MW State were explored. Results showed that correlations ranged from .38 to .82. These results suggest that who reported an higher frequency of inner thoughts behind the wheel was distracted by them regardless of context or emotional conditions. We therefore developed a MW Scale including the two items assessing how frequently drivers let their mind wander and items loading on MW State component. The internal reliability of the MW Scale was assessed calculating Cronbach's alpha revealing a value of .913. Similarly, a scale was calculated for both Use of Technology and Environmental Distraction, which Cronbach's alpha revealed a value of .681, and of .670, respectively.

5.4.2 – Correlation Analysis

A correlation analysis was performed as a further step in the analysis in order to show the relation between MW Scale, other scales previously described, demographic measures, time for being aware of MW and the ability of monitoring of attention (see Table 5.2). MW Scale was positively correlated with Using of Technology Scale ($r = .345$, $p < .001$), and Environmental Distraction Scale ($r = .500$, $p < .001$). Considering demographic measures, it has been highlighted that MW Scale was negatively correlated with age (r -.392, $p < .001$), and years of driving license ($r = -.385$, $p < .001$), whereas positively correlated with gender[8] (r = .186, p = .018). Furthermore, time for notice current contents of consciousness allows to differentiate among who are able to recognize episodes of MW and who are not. Given that, MW Scale was positively correlated with the inability to estimate time taken to notice of having thought about something else (r = .244, p = .002). On the other hand, considering who are able to report time needed to become aware of current contents of consciousness, again, a positive correlation was observed with MW Scale (r = .269, p = .002). Thus, the more you report to think about something unrelated to driving, the more likely you are to report that you do not know how long it does take to realize it, and in case of ability to report how long it does take, the more frequent you report MW episodes, the more it takes to realize that you are thinking about something else. Moreover, MW Scale was highly correlated with Attention Monitoring, namely the tendency to be distracted by other inner thoughts after having realize it (r = .707, p < .001).

Furthermore, results about the influence of demographic variables on the other two scales are briefly discussed. Use of Technology Scale was significantly correlated with demographic variables, showing that Use of Technology was negatively correlated with age (r = -.208; p = .008), gender (r = -181; p = .022), and driving frequency (r = .206; p = .009). As last, Environmental Distraction Scale was negatively correlated with age (r = -.286; p < .001).

[8] Male was codified as 0, whereas female as 1.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
1. MW Scale	-									
2. Using of Technology Scale	**.345*****	-								
3. Environmental Distractions Scale	**.500*****	**.313*****	-							
4. Gender	**.186***	**-.181***	.092	-						
5. Age	**-.392*****	**-.208****	**-.286*****	**-.328*****	-					
6. Years of driving licence	**-.385*****	**-.189***	**-.262****	**-.351*****	**.991*****	-				
7. Driving frequency	-.016	**.206****	.045	.091	.150	**.164***	-			
8. Time taken to notice MW	**.269****	.057	**.184***	-.010	-.141	-.144	-.120	-		
9. Time taken to notice MW- I do not know	**.244****	.072	.109	-.007	.013	.007	.062	-	-	
10. Attention Monitoring	**.707*****	**.362*****	**.374*****	.067	**-.307*****	**-.304*****	-.068	**.260****	**.202***	-

Table 5.2 – Correlation analysis * $p < .05$ ** $p < .01$ *** $p < .001$.

5.4.3 – Regression Analysis

Variables that showed significant correlation with MW Scale, namely Environmental Distraction Scale, Gender, Age, Time taken to notice MW, and Attention Monitoring, were entered as independent variables in the multiple regression model. Age and years of driving licence were strongly correlated ($r = .991$), thus, in order to avoid multicollinearity effects, only age was included in the model. Considering MW Scale as dependent variable, results showed that predictors together accounted for a significant part of the variance of MW Scale, $R^2 = .586$, $F(5,130) = 36.764$ $p < .001$. Furthermore, significant predictors of this model were Attention Monitoring, ß = .532, $p < .001$, Environmental Distraction Scale, ß = .237, $p < .001$, and Age, ß = -.146, $p = .024$. This result suggested that drivers that were more likely to report MW caught again their mind wander, were distracted by environmental cues, and were younger (see Table 5.3).

	Partial Correlation	ß	Sig.
Gender	.153	.105	.080
Age	-.196	-.146	.024
Time taken to notice MW	.100	.068	.253
Attention Monitoring	.591	.532	< .001
Environmental Distraction Scale	.319	.237	< .001

Table 5.3 – Multiple regression model considering MW Scale as dependent variable.

5.4.4 – Percentage distribution

As last step in the analysis, contents of mind during MW episodes, perceived changing of driving behaviour during MW episodes, and risk perception are presented. Results showed that drivers reported that MW states involved for most future planning (75.8%), personal concerns (72%), thinking back to something that you have said/done and you should not have (34.8%), thinking back to some negative past events (32.9%), and blank mind (31%) (see Table 5.4). Drivers were also asked to report perceived changing of driving behaviour during MW episodes. Results highlighted that speed is lower during MW than during attentive driving (47.2%), drivers do not remember part of the journey (41%), lateral position in the lane has changed (28.6%), it happens to brake suddenly because driver did not notice that the ahead car had braked (24.8%) (see Table 5.4).

Contents of thoughts		Consequences	
Future planning	75.8%	Speed is lower during MW than during attentive driving	47.2%
Personal concerns	72%	You do not remember part of the journey	41%
Think back to something that you have said/done and you should not have	34.8%	Lateral position in the lane has changed	28.6%
Think back to some negative past events	32.9%	It happens to brake suddenly because you did not notice that the ahead vehicle had braked	24.8%
Blank mind	31%	Speed is higher during MW than during attentive driving	20.5%
Think about something positive that could happen	28.6%	The wrong way is taken accidentally because it is crossed regularly	19.9%
Think back to positive past events	27.3%	Stare at nothing	18.6%
Think about something negative that could happen	19.2%	You do not slow down near the crosswalk	10.5%
Think about something neutral that could happen	18.6%	You do not pay attention to pedestrians	4.3%
Think back to neutral past events	16.1%		

Table 5.4 – Frequency of causes, contents, and consequences of MW behind the wheel.

As last, a brief mention to perception of risk associated to MW and to other forms of distraction. Drivers were asked to refer their opinion about risk connected to the use of technologies behind the wheel, and to think about something unrelated to driving. It was highlighted that the majority of drivers considered the use of technologies behind the wheel as highly dangerous in order to be involved in a car crash (60.2%), then fairly (26.7%), averagely (8.7%), little (2.5%), and not at all (1.9%) dangerous. On the other hand, drivers' opinion about potential negative effects of MW behind the wheel is less clear, for details see Table 5.5.

Do you think that let the mind wander while driving can be related to an increment of probability of being involved in a car crash?	
Highly	19.2%
Fairly	29.8%
Averagely	31.7%
Little	16.8%
Not at all	2.5%

Table 5.5 – Risk perception about potential negative effects of MW behind the wheel

5.5 – Discussion

The study aimed at assessing several issues concerning MW during everyday driving. Specifically, we intended to explore whether there are specific conditions that might encourage or discourage MW flourishing, the relation between MW and other types of distraction behind the wheel, and the influence of demographic variables. The questionnaire was formed by five sections (see §§ 5.3.2), and two questions assessed explicitly the frequency of MW behind the wheel. These two items were highly correlated, and a MW Frequency Scale was calculated. The Cronbach's alpha of this scale was very high revealing a good internal reliability.

The first issue concerned whether there are specific conditions that might encourage or discourage MW flourishing. A PCA with a Varimax rotation allowed to extract 3 components: MW State, Use of Technology, and Environmental Distraction. Simple correlations between MW Frequency Scale and each single item that loaded on MW State component were explored to clarify whether there were specific conditions that could affect MW occurrence. Results revealed positive correlations suggesting a general tendency to let the mind wander. In other words, who reported an higher frequency of inner thoughts behind the wheel was distracted by them regardless of context or emotional conditions. The high correlations between the items suggested the possibility to develop a MW Scale including the two items of the MW Frequency Scale and those items that loaded on the MW State component. Accordingly to this general tendency to let the mind wander suggested as results explanation, a study performed by McVay, Kane and Kwapil (2009) showed that MW can be considered as a stable cognitive characteristic across different contexts. They found that those participants that reported a higher MW frequency during tasks performed in laboratory, were the ones who reported a higher MW frequency even during everyday activities. This seemed to suggests that some participants report MW more frequently regardless of the contextual or emotional situation. Conversely, specific studies about MW behind the wheel suggested something different. For example, Berthié and colleagues (2015) highlighted that situations such as route familiarity, dullness, and being alone in the car might favour MW. Similarly, even Burdett and colleagues (2016) observed that route familiarity favoured MW episodes. However, the use of the PCA in the present study allowed to identify a multiple components model that indicated that a single factor could account for the increment of MW frequency in several different conditions. Although the general tendency to let the mind wander observed, a regression analysis highlighted also a contribution of the Environmental Distraction in explaining MW. This result suggests that thoughts unrelated to driving might be triggered by environmental stimuli, indeed everyone has own goals that could be triggered suddenly and automatically by salient cues in the environment (Smallwood & Schooler, 2006).

The second issue concerned the relation between MW and other types of distraction behind the wheel. The PCA highlighted the independence of MW from other kinds of distraction, such as the use of technology, showing the different nature of these kinds of distraction and the necessity to deal separately with them.

The third issue concerned the influence of demographic variables. Results highlighted that younger drivers were more likely to report a higher MW score on the scale. Similarly, a significant role of age was already observed in a study that explored MW behind the wheel (Burdett et al., 2016). The other type of distraction taken into consideration was the use of technology behind the wheel. Our result confirmed the gender effect observed in previous studies (Sullman & Baas, 2004; Poysti, Rajalin & Summala, 2005). Indeed even in this study males were more likely to report a more frequent use of technology while driving. Moreover, younger drivers reported to use technology more frequently. Overall, younger drivers seemed to exhibit more risky driving behaviours due to the use of technology and due to thinking about something unrelated to driving.

As last, an analysis of percentage distribution was performed in order to obtain further information about MW during everyday driving. Drivers reported that the majority of their thoughts was about future planning, and personal concerns. Such results provided further confirm to recent evidences about the interpretation of MW as a functional state (Baird, Smallwood & Schooler, 2011; Smallwood et al., 2011; Song & Wang, 2012). However, it should be considered that the driving context in which these thoughts arise might limit the benefits of these thoughts. The section about perception of risk was interesting because it shed some light on the differences in risk perception related to MW and the use of technology while driving. On one hand, it was clear that drivers considered the use of technology as potentially highly dangerous in order to be involved in a car crash, whereas on the other hand drivers' opinion about risk related to MW while driving was less clear. On the contrary, Galéra and colleagues (2012) demonstrated that MW was associated with being responsible for car crash. Our result about drivers' perception of risk about MW behind the wheel may be due to the limited drivers' knowledge about the this issue compared to the higher attention paid to raise awareness about the dangerousness of cell phone use behind the wheel.

In conclusion, this pattern of results suggests that MW does not rely on contextual or emotional conditions; it might be rather considered as a general tendency to let the mind wander, encouraged by environmental stimuli, and more frequent in younger drivers.

Chapter 6

General discussion

This thesis addressed the issue of the *mind wandering* (MW) considering domains of everyday activities such as driving and narrative discourse production. Many studies have stressed its pervasiveness both in laboratory and in everyday life, thus the investigation of this issue seems to be quite interesting especially if considered in the context of everyday life. The intrinsic nature of MW let it difficult to manipulate the when and the how often it occurs. However evidences from literature, and even from this thesis, provide confirm to the reliability of what participants referred. Indeed coherent result was observed between quality of performance and percentage of MW episodes referred. In the General Discussion several aspects are discussed: 1) the necessity of distinguishing depending on level of meta-awareness, 2) the increase of MW frequency with time on task , 3) the effect of a wandering mind on narrative discourse production, 4) a new questionnaire about inattentiveness behind the wheel, 5) whether MW affects driving behaviour and whether its effect differs according to the sampling procedure used, and 6) final considerations.

The introduction to the concept of MW provided in the Chapter 1 underlined the great importance of not considering MW as an unique construct, and the need of distinguishing between awareness and lacking of awareness of MW episodes. Indeed, the Experiments of this thesis were conducted using this distinction in order to achieve a better understanding of such phenomenon. Both in the Experiment 1 of Study 1 (presented in Chapter 2) and in Study 2 (presented in Chapter 4) the majority of the MW episodes referred were characterized by awareness underlining the conscious tendency to engage our mind in thoughts unrelated to the activity at hand, but also the difficulty of catching the moment in which the participant is unaware of her/his state of mind. An increment in the number of participants would be desirable in order to allow more specific analysis that was not possible in this thesis. For example, in the Experiment 1 of Study 1, presented in Chapter 2, some analysis were prevented for this reason. As a further confirm to the necessity of distinguishing MW depending on meta-awareness of it, in the Experiment 1 of Study 1 the regression analysis showed a different role played by Executive Functioning in explaining MW episodes characterized by awareness and those characterized by unawareness (in this case only approached the significance). The relevance of this result lies in the fact that apparently it seems to clarify the debate between the decoupling hypothesis (Smallwood & Schooler, 2006) and the executive failure hypothesis (McVay & Kane, 2009, 2010, 2012). The former suggested that executive resources are directed away from the primary task in order to allow the flow of thoughts, whereas the latter stated that executive control reduces to the minimum potential sources of distraction and MW episodes are a result of an executive failure. Part of literature results is explained by the decoupling hypothesis, whereas other studies are explained by the executive failure hypothesis. However, the majority of the studies did not control for the meta-awareness of the MW episodes, and future studies should use this distinction in order to better understand this phenomenon.

Furthermore, an increment of MW episodes with time on task was observed across different situations. For example, in both conditions (i.e., Probe-Caught and Self-Caught condition) of the Study 2, about driving skills, presented in Chapter 4, percentage of

MW increases with time on task. Also Table 2.8 presented in Chapter 2 highlights that the tendency to be on task during the SART decreases during the task. Generally speaking, when a new activity is engaged repeatedly, a gradual change from conscious control to automatic processes is observed, potentially freeing up resources which might be available for MW. Many daily activities become automatic with repetitions, an example of our interest is driving skills.

As a first domain of everyday activity, the narrative discourse production was taken into consideration. There is no evidence of studies that have explored the relation between MW and narrative discourse production. Experiment 2 of the Study 1, that was presented in Chapter 3, was conducted in order to explore whether there is a general tendency to lose the track of what is doing, specifically whether an association between a not steady performance on SART, as measured by RTCV, and the inability to convey a message effectively can be observed, and be explained by cognitive aspects. According to the literature, this hypothesis was based on the assumption that the ability to convey correct and relevant information is a complex ability that relies on the inhibition of irrelevant topics and might be considered as the ability to stay on task during a narrative discourse production. A correlation analysis highlighted a negative relation between RTCV and the component Communicative Effectiveness. Starting from this preliminary result, a further step in the analysis was to perform a PCA in order to explore whether the tendency to lose the track of the task or, conversely, to stay focused on the task is constant across different contexts. In other words, it was explored whether a general factor of derailment from the aim of the activity at hand could be extracted. According to our hypothesis, we expected that the indices of RTCV, of Communicative Effectiveness, as representative of the ability to stay on task, and of CFQ as representative of daily life, would load on the same factor with Executive

Functioning as cognitive underpinnings. On the contrary to what was expected, results highlighted two different components (see Table 3.6). Communicative effectiveness was shown to share common variance with Executive Functioning and frequency of unawareness of MW episodes (with a negative relation). No relationship was observed with the other indices considered as representative of derailment from the task (i.e., RTV, and CFQ). However, this result seems to be interesting as it suggests that the ability to prevent the tendency of being lost in thoughts, without being aware of it, could in part support an effective narrative discourse production. Moreover, in the light of the different role played by Executive Functioning in explaining meta-awareness of MW episodes, (see Chapter 2), this component gains further importance. The final point about the issue of MW in the language domain concerns the task that should be used. The nature of MW makes its study difficult and challenging. Indeed researchers do not have the direct control of MW occurrence. Moreover, in this study the story telling task was not the best task to investigate the phenomenon of MW. Indeed, despite the interesting results, a weak point of the study is the lacking of an experience sampling embedded in the task. Future studies should involve jointly produced task (Jorgensen & Togher, 2009) that are more ecological because an active cooperation among co-tellers is needed. About the experience sampling to be embedded in the task, a retrospective sampling method could be used to assess mental experience during the task given that it allows to complete the task without any interruption.

In the second part of the thesis the driving context was taken into consideration. The issue of MW behind the wheel was addressed by two studies, one of which involved the development of a new questionnaire, and the other used a driving simulated task.

Study 3 presented a new questionnaire that allowed to explore distractions behind the wheel considering both the MW and the use of technologies. The questionnaire was formed by five sections (see §§ 5.3.2), and two questions assessed explicitly the frequency of MW behind the wheel. These two items were highly correlated, and a MW Frequency Scale was calculated. Taking into consideration different kinds of distraction behind the wheel was of particular interest, indeed by using a Principal Component Analysis (PCA) with a Varimax Rotation three components were extracted: MW State, Use of Technology, and Environemntal Distraction. Results allowed to observe that MW and use of technologies behind the wheel can be considered as two independent forms of distraction. Moreover, single items of the MW State component were highly correlated with the MW Frequency Scale. This result suggested a general tendency to let the mind wander behind the wheel regardless of the emotional or contextual conditions. According to this consideration, noteworthy is the development of the MW Scale (Cronbach's alpha = .913) that included items of the MW Frequency Scale, and of the MW State. As mentioned, our result highlighted that MW might be considered as a general tendency to let the mind wander. Actually, results of the literature suggested that MW could be considered as a stable cognitive characteristic across different contexts. Accordingly to these evidences, our results provide further support to the idea of MW intended as a general tendency to let the mind wander. Future studies could deepen this knowledge by administering also a cognitive assessment to all the drivers that fill in the questionnaire in order to unveil whether a cognitive characterization could explain better this tendency. The large number of participants allowed to obtain information about a wide range of ages. Interestingly younger drivers were shown to be more likely to report an higher score on the MW scale. This result confirms literature evidences, indeed an age effect was observed in previous study (Burdett et al. 2016). Thus, these results emphasize the need of raising awareness about such kinds of distraction behind the wheel, especially in some range of ages, in order to increase road safety.

To further study the issue of MW and driving skills a simulated driving task was used in order to directly explore MW effects. In the Study 2, presented in Chapter 4, a lane-keeping task was used to study the basic driving skills. Probe-caught and self-caught sampling procedures were embedded in the driving task in order to explore whether MW affects driving behaviour and whether its effect differs according to the sampling procedure used. Results of the study highlighted that inattention deriving from MW does not significantly affect the basic driving skills involved in the lane-keeping task, and draw attention on the critical implications that the use of the two sampling methodologies has in the context of the study of MW on driving performances. On the one hand, the self-caught procedure may be more suitable for studying the detrimental effect of MW on driving performances, whereas on the other hand the probe-caught procedure can inform on the nature of the strategic responses to distraction derived from MW. Future studies should consider the car-following task in order to explore how the reaction times to depress the brake pedal change depending on the thoughts sampling methodology used. Thus, it should be explored whether the effect of MW on reaction times to sudden events varies according to the different mental states as detected by different sampling procedures (i.e., probe-caught, and self-caught).

In the light of these results, they seemed to allow interesting considerations. As first, information about methodological issues is provided by the studies presented in this thesis. For example, the Study 2, presented in Chapter 4, intended to compare the two main thought sampling procedures commonly used, namely the probe-caught and the self-caught sampling procedures. In the context of driving performance it was shown that these two methodologies allowed to explore different aspects of MW. Indeed, by using the self-caught methodology participants were asked to refer every time they noticed their mind wanders, thus the awareness of their contents of mind was mainly explored. Conversely, the probe-caught methodology consisted of probes presentations at random intervals which implies that participants might be caught in a MW mental state characterized by awareness or lacking of awareness. The main difference between the two methodologies concerned the investigation of direct consequences on driving performance in case of self-caught sampling (or in case of MW states lacking of awareness as measured through probe presentation), and of intentional driving changes in case of probe-caught sampling. A further methodological issue was investigated: the necessity of characterizing MW mental states. The majority of the literature studies compared only on-task and off-task thoughts. However, recent evidences suggested that the MW should not be considered as an unitary construct, rather it should be distinguished depending on level of awareness (Seli, Risko & Smilek, 2016b). Actually, our results highlighted the differences between MW episodes characterized by awareness and those lacking of awareness. Specifically, a different role played by the Executive Functioning was observed showing that cognitive aspects seemed to be a key aspect in understanding the phenomenon of MW. However, it should be remembered that the relation between MW episodes lacking of awareness and the Executive Functioning only approached the significance, and an increment of the number of participants might clear this result.

Generally speaking, as mentioned in the Chapter 1, MW is known to affect the performance of the task at hand. However, MW was shown to play even a functional role determining a positive consequences. For example, it is thought to arise due to current concerns (Klinger, 1999), thus the MW contents might be represented by future planning or anticipations of own goals (Mooneyham & Schooler, 2013; Smallwood &

Schooler, 2015). It is clear that future planning or anticipation might have benefits on personal's life. However, the core problem about the relationship between costs and benefits of MW depends on what we are doing. For example, results about the questionnaire of inattentiveness behind the wheel presented in this thesis showed that the contents of thoughts of the majority of the drivers were about future planning and personal concerns. Considering the context of daily driving, the potential benefits of MW seemed to be reduced because its consequences can be risky for road safety. Additionally, Experiment 1 of Study 1 highlighted that the frequency of thought that are considered as unrelated to the task at hand is negatively correlated with the interest in the task at hand. Our mind is able to disengage itself from the external environment to engage in another train of thoughts in order to overcome boring or tedious task or situation. This is a possible function of MW, however, as mentioned above, there might be a price to pay when we think about something unrelated to the activity at hand. Indeed, results of this Experiment confirmed previous evidences about the costs of MW on SART performance, as measured by a greater RTCV. Differently from other results that show a negative effect of MW on performance, basic driving skills, as measured during a lane-keeping task, were shown not to be affected by MW mental states characterized by awareness. Again, this result stressed the relevance of distinguishing depending on level of awareness of mental state. Future research might consider the car-following task in order to assess whether the effect of MW on driving behaviour, as measured for example drivers' response to sudden critical events (i.e., braking of the leading car, pedestrians). In addition to the consequences of MW on task performance as measured by behavioural indices, it was shown that MW is even associated to physiological ones. For example, eye movement, pupil dilation, skin conductance response, and heart rate were studied as physiological correlates of MW (Franklin, Broadway, Mrazek, Smallwood & Schooler, 2013; Reichle, Reineberg & Schooler, 2010; Schad, Nuthmann, & Engbert, 2012). Physiological indices might be of main interest for practical implications. For example, considering that MW was associated with faster heart rate during laboratory tasks (Smallwood, O'Connor, Sudberry, Haskell & Ballantyne, 2004), further studies might consider the driving context in order to potentially implement an heart rate device in the car. It was speculated that the increment of the heart rate was due to the emotional aspects that characterized the MW contents. Another possibility might be the monitoring of the eye movemen. About this possibility He and colleagues (2011) showed that during MW drivers tended to focus their attention narrowly providing an example of a direct consequences of MW that might provide useful information during driving.

It should be mentioned that as long as MW plays its role of autobiographical planning and anticipation, it can be considered as adaptive, however these thoughts sometimes might become repetitive not being adaptive anymore. About that, it was suggested that perseverative cognition might represent a risk factor for well-being (Ottaviani, Shapiro & Couyoumdjian, 2013), and a MW – perseverative cognition continuum was proposed, in which the former represents the functional extreme and the latter the pathological one (Ottaviani, Medea, Lonigro, Tarvainen & Couyoumdjian, 2015; Ottaviani et al., 2013).

In conclusion, another positive aspect that should be stressed is the ecological validity of this thesis. Indeed, considering the well know effects of MW on laboratory tasks and its pervasiveness during daily life (e.g., daily activities, lectures, driving, reading), the guiding idea was to explore domains of daily activities in order not to limit the exploration to the laboratory task, rather to explore the potential MW effects on domains of daily performances. Our results are of particular interest because tasks that were administered might be performed even out of the laboratory, and are part of our daily life. For example the driving simulation allowed to drive by using a wheel and pedals as if participants were driving they own car. Even though the simulation is not exactly as driving in real life, it represents the best option in order to study driving skills, since conducting an experiment during naturalistic driving might be risky and not ethically correct. In addition, the SART is considered as a task characterized by ecological validity (Smilek, Carriere & Cheyne, 2010), and eventual failures during this task seem to mirror a trend in everyday life. The other domain taken into consideration was the discourse production. It might represent another promising field of research that should be investigated deeply.

Appendix

1. Le capita di leggere qualche cosa e di non aver prestato attenzione a quanto letto ed essere costretto/a a rileggerlo?

2. Le capita di dimenticare il motivo per cui è andato in un'altra stanza?

3. Le capita di non notare i cartelli stradali per strada?

4. Le capita di confondere la destra e la sinistra quando dà indicazioni?

5. Le capita di andare a sbattere contro le persone?

6. Le capita di non ricordare se ha spento le luci o il gas o chiuso la porta?

7. Le capita di non prestare attenzione ai nomi delle persone appena conosciute?

8. Le capita di dire qualche cosa e di pensare subito dopo che potrebbe essere stata pensata come un insulto?

9. Le capita di non ascoltare le persone quando parlano, quando è impegnato a fare qualcosa?

10. Le capita di arrabbiarsi e di rammaricarsi di questo?

11. Le capita di lasciare delle lettere importanti senza risposta per più giorni?

12. Le capita di dimenticare di girare in una strada che conosce bene ma raramente usa?

13. Le capita di non trovare quello che cerca in un supermercato anche se il prodotto è presente nel supermercato?

14. Le capita di chiedersi se la parola che ha appena usato è corretta?

15. Le capita di non riuscire a spiegare quello che ha in mente?

16. Le capita di dimenticarsi gli appuntamenti?

17. Le capita di dimenticare dove ha lasciato qualcosa come un giornale o un libro?

18. Le capita di buttare via quello che voleva tenere e tenere quello che voleva buttare (per esempio: buttare la scatola di fiammiferi e tenere il fiammifero usato)?

19. Le capita di perdersi nei suoi pensieri quando dovrebbe stare ad ascoltare?

20. Le capita di dimenticare i nomi delle persone?

21. Le capita di iniziare a fare qualcosa dentro casa e di trovarsi a fare distrattamente qualcos'altro?

22. Le capita di non riuscire a ricordare qualcosa pur avendo la sensazione di averlo sulla punta della lingua?

23. Le capita di dimenticare cosa aveva intenzione di comprare in un negozio?

24. Le capita di far cadere le cose?

25. Le capita di non riuscire a pensare a qualche cosa da fare?

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