Processing Destination Memory in
Young Adults: An Exploratory ERP Study

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the University of Minho.

Vasco Ribeiro Ferreira

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Abstract

Destination Memory (DM) refers to the process of retrieving past information about the specific destination or recipient of an action. DM has increasing interest due to its novelty. We intended to study the brain dynamics occurring in a DM task. To that end, an EEG recording compatible computer task was developed in which participants distributed objects between 2 geometric figures. Later, they had to remember in which figure they had sent that object to, by placing them again in the same one. In this last phase, new objects were also introduced and participants had to distinguish between previously placed objects (Old Objects) and objects seen for the first time in the task (New Objects). Further, Openness personality traits were assessed with memory performance since studies mention possible connections. The sample included 21 participants. Results showed a difference between Old and New Objects in the Occipital region for the mean EEG amplitude between 300-450ms, with larger negativity for Old Objects. Regarding personality, only Extraversion revealed a significant negative correlation. This study was the first assessing brain dynamics during a DM task. Activity differences may be restricted to late information processing stages. Further, it highlights the potential relation between Extraversion and DM.

Keywords: destination memory, electroencephalography, episodic memory, personality, young adults

Processamento de Memória Destino em Jovens Adultos: Um Estudo Exploratório de Potenciais Evocados

Resumo

Memória Destino (MD) refere-se ao processo de recordar informação passada direcionada a um recetor específico de uma ação. O interesse em estudar MD tem aumentado, sendo novidade na literatura. O objetivo consistiu em compreender as dinâmicas cerebrais que ocorrem numa tarefa MD. Assim, os participantes realizaram uma tarefa computorizada com EEG, na qual distribuíram objetos por 2 figuras geométricas. Mais tarde, recordaram onde o objeto foi enviado, colocando-o de novo na mesma figura. Nesta última fase, novos objetos foram também introduzidos, aos quais os participantes teriam de distinguir entre Objetos Novos e Velhos. A amostra foi constituída por 21 participantes. Associações entre a performance e a personalidade de Abertura foram exploradas, sendo que estudos mencionam possível relação. Foi possível concluir que existem diferenças entre o processamento de Objetos Novos e Velhos. Ao nível das regiões Occipitais, na amplitude média entre 300-450ms, a atividade revelou maior negatividade para Objetos Velhos. Relativamente à personalidade, apenas a Extroversão apresentou estar correlacionada de forma negativa com a performance. O estudo foi o primeiro a abordar MD com técnicas de EGG. Diferenças na atividade podem estar restritas a informação processada mais tardiamente. Evidencia ainda uma potencial relação entre Extroversão e MD.

Palavras-chave: eletroencefalograma, memória episódica, memória destino, jovens adultos

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Abbreviation List

ANOVA – Analysis of Variance

ASR – Artifact Subspace Reconstruction

BOSS –Bank of Standardized Stimuli

CMS – Common Mode Sense

DM – Destination Memory

DRL – Driven Right Leg

DUDIT-E – Drug Use Disorder Identification Test-Extended

EEG – Electroencephalography

ERP – Event-Related Potentials

fMRI – functional Magnetic Resonance Imaging

ICA – Independent Components Analysis

LPN – Late Posterior Negativity

NEO-FFI-20 – Neuroticism-Extraversion-Openness Five-Factor Inventory 20

SM – Source Memory

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We all seem to have some understanding of what memory might be, but when talking about memory, the fact that it is a one-word concept might mislead to the thought that it corresponds to a singular system working in a holistic way with cognition. In fact, memory is constructed by a group of systems that can work independently and have complex distinctive functions in cognitive processing.

The experimental research on memory has been ongoing for decades, and even though we have a good notion about its entirety, presently we still do not fully understand memory in all of its structure. Following Baddeley's publication (1997), it is easy to recognize the importance of studying memory in a variety of domains. The author distinguishes between sensory, short-term and long-term memory. These divide in a wide network of subtypes, mainly in long term processing, where we can have explicit (conscious) and implicit (unconscious) processing.

Studying Memory

Although uncovering the cognitive processes behind memory or their structure is relevant for research, the author himself underlines that the importance of it doesn't rely solely on understanding such structures, but ultimately culminates in self-discovery. In other words, the story of who we are can be told via the set of experiences we have lived in the past and the ones we are living right now. Even if we don't remember everything, that does not necessarily mean those experiences are not a part of memory; it has been shown that they're stored with a crucial role of the hippocampus, guiding our thoughts and behaviour and making us who we are (Travaglia, Bisaz, Sweet, Blitzer & Alberini, 2016).

Episodic memory is responsible for storing past events that occurred in our lives and is, therefore, involved in recalling such experiences while also integrating autobiographical aspects (Baddeley, 1997). This reflects just how relevant it is to deepen the ongoing research on the memory field, making it just not about research but also for a better understanding of ourselves, our attitudes and behaviour.

Memory and Social Cognition

Overall memory capacities seem to be essential in interpersonal relationships. Recalling information obtained or given in previous social situations might prove to be a determinant of successful social interaction. In his work, Spreng (2013), talked about the importance of memory in social cognition by stating that social dynamics are complex and unpredictable, and that it may be fundamental to anticipate such dynamics. The facilitating process of social navigation, according to the author, may be possible due to the interaction of episodic memory and inferring the mental states of others (Theory of Mind); episodic memory allows us to project our own memories onto others, imagining their own experiences, producing a feeling of empathy. Also, during social interactions, these personal experiences are integrated to form a sense of collective identity.

The importance of memory in interpersonal relationships may also be evidenced by the lack of memory itself: a study with three amnesia patients (two with adult-onset and one with developmental amnesia) showed that these patients have more difficulties not only in forming new social bonds but also in maintaining them (Davidson, Drouin, Kwan, Moscovitch & Rosenbaum, 2012). The adult-onset cases essentially only had close relationships within their family, while the one with developmental amnesia was able to form bonds outside the family (despite dealing with the condition throughout life). Overall, all three patients seemed to have a smaller social network when compared to normative cases.

The Role of Destination and Source Memory

It is not difficult to imagine a daily situation in which memory (and episodic memory in particular), has had a direct impact on our relationships. An inability to recall to whom we might have told a piece of information, repeating it to the same person (or in other cases, the same group of people) will not improve the relationship itself and may even have a possible negative impact, as suggested by Gopie and MacLeod (2009). For example, we might not be sure we told family member A or B that we are moving away from our hometown, so we tell them again.

When talking about recalling information sent previously to a receptor (or destination) we are referring to Destination Memory (DM), a type of episodic memory; this term was first proposed by Koriat, Ben-Zur and Sheffer (1988). On the other hand, when trying to retrieve information that we got from another entity (a sender) we are talking about Source Memory (SM). It is rather clear that both of these concepts belong within Episodic Memory, since the two involve remembering past experiences and information, even though they go further than that, by identifying a receptor – DM, or a sender – SM. Episodic memory seems to be correlated with DM, and a decline in one can be seen in the other, as demonstrated by El Haj, Allain & Kessels (2014); the authors also pointed out that executive function and its inhibition processes might be behind the retrieving abilities, since inhibitory control plays an important role in selective attention abilities (e.g. ignore irrelevant information).

Even though the focus is on DM, it makes sense to establish a clear contrast between DM and SM. They seem to be interconnected since DM represents a situation in which one has to remember a past event, such as placing an object or telling a story; while SM corresponds to the opposite: when we recall an event with an external source. Both mechanisms involve situations that happened in a previous context, they seem to be associated with context memory capacity, considering they involve remembering background information that occurred in a specific place at a specific time (El Haj, 2016).

A Destination Memory Framework

El Haj and Miller (2017) made clear in their work that DM is heavily influenced by social factors and by the properties of social interaction. They start by emphasizing the role of the context where the event occurs (typically an exchange of information involving a receptor), and its role in later recalling that information. They explained that there is an association between the context and the event it occurs in called binding, and the stronger that association is, the higher the probability to retrieve the information successfully. Besides this association, social aspects also interact within retrieval: familiarity with destination, stereotypes, cognitive and emotional states all play a part in encoding for destination information. For example, the more familiar we are with the receptor, the more likely we are to remember who it was later on.

Older adults (that tend to perform worse than younger adults) rely more on stereotypes when retrieving DM, which means that, often, these attribute their own beliefs to the content of the information being exchanged. It serves as a cue to be more easily associated with a determined receptor. For example, if the nature of the conversation was conservative politics, they may remember the other as being right-winged. Consequently, these associations based on stereotypes are often faulty.

Cognitive states are also involved, especially when taking into account that DM is dependent on executive function abilities such as set-shifting and inhibitory control, thus when these are compromised or there is the presence of dementia or other cognitive disabilities, retrieval is also affected.

Lastly, the emotional state of an agent, a receptor, or the emotional content of the event itself can be helpful for recall; when we are telling a sad or happy story we are more likely to remember it, even more so when the receptor also reflects those emotions.

It becomes clear how social factors can have a heavy influence when it comes to DM, so the authors proposed this framework as the social cognitive model (El Haj & Miller, 2017).

Destination Memory and Research

Literature shows massive research done in the SM field, including behavioural and functional data; on the other hand, research on DM seems rather scarce, with a particular lack of neuroscience studies. Recent studies have shown empirical differences for both SM and DM.

Gopie and MacLeod (2009) were the first researchers to study DM in an experimental context, and they had participants either telling facts to famous faces (a DM condition) or learning them from the famous faces (a SM condition). Even though DM revealed lesser scores than SM in recall (meaning there's a poorer performance when we try to remember to whom we told something, rather than who told us something), it was later demonstrated in a subsequent experiment that when self-focus is reduced, the effect is reduced. The authors explained that the major part of errors might be due to a higher self-focus in telling a story and focusing on the processes of transmitting information, and that shifting that self-focus and attention to the other person might reduce that error, increasing recall for DM.

El Haj's study (2016) using both young adults and older adults demonstrated that younger adults usually register higher memorability rates in a recall task when compared to older ones, and when participants perform the memory task themselves they retrieve the information better, reducing the gap between younger and older adult's performance. However, when the task was executed by an experimenter the subjects showed higher difficulty retrieving information, for both DM and SM. The author also concluded that SM tasks overall register higher memorability capacity when compared to DM tasks. These findings should be taken into account when designing the task, for example, dividing the sets of stimuli into smaller clusters might increase memorability performance, as developing a self-generated task instead of an experimenter-generated will likely have that same outcome.

Studies in DM also wanted to determine if deception (e.g. inducing a false belief in others) played any type of role in memory. The task consisted of a series of trials involving seeing faces of famous people and telling them proverbs. Afterward, they had to remember if the proverb that appeared was told to the face being shown. Results showed that when deception levels were higher in participants, DM also showed higher retrieval rates, revealing a positive correlation between deception and DM. This indicates that people that tend to deceive more are also more aware of lies told and to whom they were told to, showing good DM capacity for deception. Theory of Mind was also analysed and its possible influence in performance. The conclusion was that DM seems to be a mediator between deception and Theory of Mind (El Haj, Antoine & Nandrino, 2017).

Performance and Personality

It has been widely suggested that memory can be influenced by a series of factors, and that these can even pose as predictors of performance on a memory task. Lately, it has been shown that personality can impact the memory field, especially after the finding that a few of the Big Five personality traits may be associated with certain types of memory; for example, people with neuroticism have been shown to have a wider range of negative memories (Ruiz-Caballero & Bermúdez, 2010). But can we establish any type of link between personality and, in this case, DM? Primarily, it seems that a few traits can be traced back to autobiographic memory. This might be due to the fact that the emphasis on a few traits will imply a change in self-perception and perception of our own actions and experiences, as well as the perception of others.

Studies have suggested that a higher Openness to Experience might be behind a higher reflection of the person on their inner experiences, with more Openness also being related to a higher structure complexity for self-defining memories (Rasmussen & Berntsen, 2010). This particular study showed important advances in such findings, since they were able to strongly correlate Openness to Experience with different dimensions of autobiographic memory (and therefore also episodic memory). Turns out that highest scores for directive, self and social dimensions of autobiographical memory are correlated with highest scores in Openness to Experience, with the dimension of the self being very strongly associated. This trait of personality was the only one to reveal such consistent findings, whereas others varied slightly across studies and tasks (Rasmussen et al., 2010).

As explained earlier, this translates an emphasis on the inner experiences of the self, therefore leading to more awareness of past experiences and improved recall. However, it is risky to predict that participants with higher scores in Openness to Experience in the NEO-FFI-20 will also have a better performance in a DM task, especially knowing that a higher self-focus and focusing on the process of exchanging information will translate into poorer retention of DM. Taking that into account, it is possible that a negative relationship will be found between them.

Neuroscience Contributions

The remaining questions surrounding DM are those relative to neuroanatomical activity. The neuroscience field has dedicated little research to such questions, with only one functional Magnetic Resonance Imaging (fMRI) study of Mugikura, Abe, Ito, Kawasaki and Ueno (2016), that focused on the medial temporal lobe, the region where memory for facts and events resides. In the first part of the task, random facts were shown, followed by the face of a man or a woman. Later, participants had to decide if the facts presented were new or included in the first part, in which subjects had to tell if they were highly or lowly confident that the fact was followed by the face of a man or a woman. Results showed more activation on the left parahippocampal gyrus, left orbitofrontal cortex, right superior occipital gyrus and right inferior occipital gyrus for successful retrieval. Even though the study shows a main activation of the medial temporal lobe, the orbitofrontal cortex activation reveals a role of the frontal areas, evidencing the importance of such regions in DM, as suggested before (executive function processes and inhibitory control). The activation of the parahippocampal gyrus also confirms the central role of context when encoding for DM; it makes sense that when recalling information, focusing on the context where the encoding occurred will help to remember it, hence activation of the parahippocampal region (Hayes, Nadel & Ryan, 2007).

Electroencephalograms (EEGs) are often used during memory tasks as well. The EEG is a non-invasive electrophysiological technique which consists of putting a cap on the scalp with the purpose of registering brain electrical activity via a number of distributed electrodes present in said cap. Since it relies on the activity closer to the surface, analyzing at a deeper subcortical level is harder with the use of EEG, however it is more than good at representing the activity pattern that occurs over time. Therefore, the main purpose of the use of EEG with DM would be as to determine the specific timings (brain dynamics) in which the processes occur, both encoding and retrieval, that otherwise would not be grasped with the use of other techniques such as fMRI. Even though its precision in spatial resolution isn't as good as fMRI techniques, the electrodes will give us the main components present when retrieving DM. This means that the results will be more of an observation of the different electrodes activated during the performance of a DM task and at what times the activations occur, rather than a clear representation of the area involved (Cohen, 2017). Still, this constitutes a good complementary technique to the previous existing fMRI study, since temporal dynamics in DM have not been assessed until now.

Study Aims

Until now, no EEG studies were developed with DM tasks, so functional data obtained with this equipment is currently unknown of. On that note, the aim of this study focuses on using the high temporal resolution of the non-invasive EEG techniques, as to better understand the dynamic processing of the brain during a DM task, contributing to giving some answers lacking on the investigation field dedicated to this type of memory. It would be interesting to uncover the processing differences between successful and unsuccessful recall of stimuli in DM. It is possible that the processing of said stimuli during an encoding phase could be crucial for a subsequent task of recall.

Concerning personality, it is possible that some differences may be found among the test scores of the sample and their performances on the memory task. Since particularly in DM a higher self-focus usually indicates a decline in performance, the prediction is that a higher Openness to Experience in participants will reflect lower retrieval rates for DM.

With the aid of EEG, we would be able to see if any diverging patterns during the encoding of certain stimuli would lead to correct or incorrect answers in later remembering them. Thus, allowing us to observe further than motor actions, with also being able to understand the perceptual process that occurs. By doing this, we ultimately aim to shed some light on the conditions that successful DM retrieval occurs in the brain.

Since no studies were developed before using EEG techniques, and given the exploratory aspect of the present study, no predictions to brain activity were made. Although no hypotheses were established, it is expected that DM tasks reveal a similar pattern to SM tasks due to the close connection between the two. For instance, activation of the Late Posterior Negativity (LPN) component is rather expected, since it is present in most episodic memory tasks, as well as in SM studies (Mecklinger, Rosburg, & Johansson, 2016). The LPN usually peaks at about 400-500ms and can be mostly seen in the parietal-occipital regions, particularly on the POz electrode. It has been shown that this LPN component is essential when retrieving information related to past experiences and their context, making it possibly important in DM. This component also lets us set apart correct from incorrect judgments in memory, as shown in the SM task of Mecklinger, Rosburg and Johansson (2016). The investigators also demonstrated that the LPN is not present during the processing of new stimuli, when compared to the ones shown before. Apart from the LPN, it would be interesting to observe which other components are involved within DM.

Method

Participants

A sample of 24 young adults between the ages of 18 to 29 took part in the study. The sample was taken from the University of Minho students and the surrounding area, thus representing a convenience sampling process. Exclusion criteria involved that participants did not have a psychiatric disorder or a medical/neurological condition, as well as no current pharmacology treatment or abuse of psychoactive substances. One participant was excluded due to their clinical history, and two others due to missing data. After exclusion criteria, 21 participants were left (M = 22, SD = 2.60). Participants were attributed with extra credit for participating in the experiment.

Instruments

Clinical History Interview. A series of questions were answered by participants on paper before beginning data collection, as to determine whether they have had a past of medical or psychiatric conditions that could interfere with their performance on the task. If that was the case, the data would not be used.

Drugs Use Disorder Identification Test Extended (DUDIT-E). (Berman, Palmstierna, Kallmén, & Bergman, 2007). The test allowed us to observe if participants may have had consumption of substances that may lead to an influence on their performance and brain activity, consequently altering data. It is composed of a set of quick questions to determine substance use patterns, that allowed us to extract a Total Consumption Index.

Edinburgh Handedness Inventory. (Oldfield, 1971; Portuguese version: Espírito-Santo, Pires, Garcia, Daniel, Silva & Fazio, 2017). The inventory determines if the participants' dominant hand is left or right so we can consider laterality among the sample. Participants had to answer a series of 10 questions about daily tasks and which hand they used in each. Each question rated from 1 to 5 on a Likert-type scale. The final scores varied between 10 and 50 points, whereas a score up to 25 would mean the participant is right-handed, a score of 26-34 ambidextrous, and 35-50 left-handed. The sample included 20 right-handed participants and 1 ambidextrous.

NEO Five-Factor Inventory 20 (NEO-FFI-20). (Costa & McCrae, 2004; Portuguese version: Bertoquini & Pais-Ribeiro, 2006). This short version of the personality test NEO-PI-R allowed us to compare the participants' different personalities and their performance on the task. A Portuguese version validated by Bertoquini and Pais-Ribeiro (2004) was used. The test was devised to analyse the five big traits of human personality: Agreeableness, Conscientiousness, Neuroticism, Openness to Experience and Extraversion. It is composed of 20 questions, including seven inverted items, displayed with a Likert-type scale from 0 "strongly disagree" to 4 "strongly agree". Each of the Five Dimensions scored from 0 to 16 points.

Stimuli

A set of 192 visual stimuli were selected from the Bank of Standardized Stimuli (BOSS) database (2010). 128 of these were used as old stimuli, whereas the other 64 were presented as new stimuli. This means that one phase would include a certain set of stimuli (the Old Objects) and that in a subsequent phase these would be shown along with newly presented stimuli (the New Objects). Their selection was made mainly based on familiarity values, as to not find significant differences between the pictures of both kinds, since familiarity may have an influence in remembrance. An independent samples t-test revealed no differences in familiarity for Old (M = 4.27, SD = .37) and New (M = 4.36, SD = .05) Objects, t = -.24, p = .82.

Data Collection

Participants were asked to present themselves at the Psychological Neuroscience Lab of the University of Minho at the time set previously with the investigators. The EEG was prepared in the EEG room of the Lab. An EEG is a non-invasive risk-free technique that focuses on recording brain activity. Event-Related Potentials (ERPs) correspond to a type of analysis with EEG techniques that allows the study of brain electrophysiological activity across time, during a certain type of event. Given that our participants will be performing a task (a cognitive event), with ERPs we will obtain waveforms depicting peaks in activity (also called components) that responded to elements of that task (Kappenman & Luck, 2011). In this way, we are able to compare brain responses according to different moments of the event.

Before starting the experiment, participants' head was measured to get the cranial perimeter, as well as the distance from inion to nasion for cap fitting purposes, as to appropriately set the electrodes on the head. After choosing the cap, 64 electrodes were set using the 10-10 international system positioning for EEG recordings. 5 external electrodes were placed on the head: one above and one below the left eye for vertical eye movements registration, two near the outer canthi of the eyes for horizontal eye movements registration, and one on the Tip of the Nose (ToN) to serve as an offline reference. The signal was obtained using the ActiveTwo Biosemi electrode system. Two extra electrodes were placed on the scalp, substituting the ground electrode (that takes into account possible noise in the channel), to allow for the recording to be continuously referenced to a Common Mode Sense (CMS) active electrode (placed between POz and PO4) and a Driven Right Leg (DRL) passive electrode (between POz and PO3). Impedances considered for starting collection varied between values of ±30mV.

Procedure

After the EEG equipment was set, participants were sat in front of a computer while being told to try not to move as much as they could. Two baselines were recorded: one with open eyes and another with eyes closed, each recorded for 180 seconds. The experiment was based on the one used in El Haj's study (2016) to evaluate DM for self-generated actions. By considering the task presented in the said study, one was developed in a similar way that also allowed us to observe destination recall. In a first stage of the task, a series of 128 pictures kept appearing centered at the bottom of the screen, as two geometric figures (a triangle and a square) were placed in each corner of the top of the screen. The final version was divided into 8 blocks of 16 pictures each, appearing in random order, with 25-second breaks between the blocks. The task in this first stage consisted of distributing the appearing images in no particular order through both of the geometric figures mentioned above. The only instruction was that each of the two figures at the end of each block had to contain no more than 8 pictures in them (half of the stimuli in each); to help them keep track of the count, every time they dragged a picture to a figure a number would appear on top of it, indicating the total of objects it already contained. Participants performed this experiment with a mouse, and the dragging movement was not taken into account, only the figure they chose was.

After the first task was finished, two interpolated experiments in which they had to perform a flanker task were presented to the participants. The first consisted of an emotional flanker, where a series of faces kept appearing at the middle line of the screen, and participants had to focus on the middle face and tell if it was happy or angry. The other flanker experiment was rather similar, but this time around participants had to tell if the middle face was a man or a woman. The answers were given by pressing one of two keyboard keys. These two interpolated tasks were counterbalanced across participants in terms of the order they were presented in. Each of these had a duration of 10 minutes.

In the final stage of the experiment, the geometric figures were again shown on the screen, this time leveled at the center: one on the right side and the other on the left side of the screen. There was also a Pentagon figure in this recall task, standing on the top center of the screen, in case participants were not able to remember the Object. A Star was also displayed along, centered at the bottom of the screen, in which participants would place New Objects. Both the Star and the Pentagon remained on the screen throughout this phase. The 128 pictures they previously dragged to the geometric figures (Old Objects) were now appearing in the exact center of the screen one by one (after each answer). Participants saw the Objects they previously dragged to either the triangle or the square and had to place them on the same location as before. Also, a set of 64 New Objects were introduced in this phase in a random order (in between Old Objects), and participants had to determine if they were, in fact, new. In case they were, they would place them in the Star. The mouse was again used in this task. Overall, the experiment lasted for about 90 minutes.

These answers generated information on Old Correct and Incorrect Objects, new Correct and Incorrect Objects, New and Old Unrecognized Objects, and False New Objects, as well as the Reaction Times in each trial and category. Accuracy in both Old and New Objects was measured. Accuracy in Old was given by the percentage of correctly placed Old Objects in recall out of the 128. Accuracy in New Objects corresponded to correctly recognized New ones, out of the 64.

Data Analysis

MATLAB R2016a software was used to import EEG raw data from Biosemi and subsequent analysis, using EEGLAB toolbox (Delorme & Makeig, 2004). Data were filtered using a band-pass filter from 0.1 to 30Hz. External (ocular) channels were removed, while the Tip of the Nose was used as a reference channel. To remove noisy channels, data was filtered in each taking into account correlations between neighbouring electrodes; in case the correlation was inferior to 0.75, the channel was considered noisy and eliminated. Likewise, channels with activity bursts were removed using Artifact Subspace Reconstruction (ASR), that detected unusually high amplitude data. Eliminated channels were later interpolated using spherical splines approach, that mathematically compares good and noisy data and corrects bad channels. Independent Components Analysis (ICA) was run to detect channels containing artifacts due to heartbeat, eye movements, and head muscle contraction; these were later removed. Epochs were segmented given a window from -150 to 1000. The ones contaminated with artifactual activity were removed if they exceed a voltage threshold of ±100μV at any time point or if they have a difference higher than 50μV between two consecutive time points. P1, P2 and N1 components' peak amplitude and latency were measured using windows of 80-150ms, 150-275ms, and 150-250ms, respectively. For the P1 and N1 components, the electrodes considered were P1 and P3 (Parietal Left), Pz (Parietal Midline), P4 and P8 (Parietal Right), PO7 and O1 (Occipital Left), Oz (Occipital Midline), and PO8 and O2 (Occipital Right). For the P2 component, the included electrodes were F3 and F7 (Frontal Left), Fz (Frontal Midline), F4 and F8 (Frontal Right), C3 and T7 (Central Left), Cz (Central Midline), and C4 and T8 (Central Right). Mean amplitudes considered all the electrodes mentioned. The data was then extracted to IBM Statistics SPSS 23 software, where channels were grouped in terms of their brain region, laterality and Old or New Object group.

Statistics for functional data and behavioural data were also performed using SPSS software, by running a Student's t-test for independent samples. The comparisons between Old and New Objects in the recall phase (Accuracy and Reaction Times) were measured using a Repeated Measures ANOVA. NEO-FFI-20 data were analysed with Pearson's Correlation, between personality scores and task performance. We intended to observe the differences between Correctly remembered Objects in contrast with Incorrect answers in Old Objects; however, due to the small number of errors, these comparisons were not possible.

Results

Behavioural Data

Table 1

Behavioural data for performance by gender

Performance	Total Sample	Female	Male	t	*p*
	M (SD) n = 21	*M (SD)* n = 15	*M (SD)* n = 6		
Accuracy Old Objects	69.64 (16.22)	72.66 (16.35)	62.11 (14.44)	1.38	.19
Accuracy New Objects	89.06 (14.29)	92.5 (12.81)	80.47 (15.30)	1.84^{+}	.08
Reaction Times – Old Objects	1659.99 (354.86)	1560.82 (289.33)	1907.91 (407.55)	-2.21^{*}	.04
Reaction Times – New Objects	1407.24 (298.60)	1294.95 (149.98)	1687.95 (401.59)	-2.33^{+}	.06

* $p < .05$

An independent samples t-test was performed to explore behavioural differences between the two groups of gender. Results showed no significant effect for accuracy in Old Objects, t = 1.38, $p = .19$, even though there seems to be a tendency for accuracy to differ in New Objects, t = 1.84, $p = .08$ (see Table 1). In terms of Reaction Times, there seems to be a significant difference between gender for Old and New Objects.

A repeated measures ANOVA was performed to assess participant's accuracy in both Old and New Objects. The test determined that there was a significant difference between recognized Old and New Objects, $F(1,20) = 55.17$, $p < .001$, $\eta^2 = .72$. Pairwise comparisons adjusted to Bonferroni revealed that Old Objects corresponded to poorer performance when compared to New Objects, $p < .001$.

The same analysis was applied to Reaction Times data for correctly recognized Old and New Objects. This revealed a significant difference between Reaction Times, $F(1,20) = 19.86$, $p < .001$, $\eta^2 =$ 50. Pairwise comparisons adjusted to Bonferroni showed higher Reaction Times for Old Objects, when compared to New ones, $p < .001$.

Table 2

Statistics assessed for personality scores by gender

Personality	Total Sample	Female	Male	t	*p*
	M (SD) n = 21	*M (SD)* n = 15	*M (SD)* n = 6		
Neuroticism	6.62 (2.40)	6.67 (2.26)	6.5 (2.95)	.14	.89
Extraversion	9.86 (1.85)	9.6 (1.72)	10.5 (2.17)	-1.01	.33
Openness to Experience	10.48 (2.56)	10.6 (3.48)	10.17 (3.71)	.25	.80
Agreeableness	9.67 (2.44)	9.53 (2.53)	10 (2.37)	-.39	.70
Consciousness	11.67 (2.03)	12.07 (1.75)	10.67 (2.50)	1.47	.16

* $p < .05$

To assess the differences of scores concerning personality, an independent samples t-test was used with the sample divided by gender. No significant effect was found between groups in Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness (see Table 2).

Table 3

Pearson correlations for performance and personality

Personality	Accuracy Old	Accuracy New	RT Old Correct	RT New Correct
Neuroticism	.11	.11	.20	.21
Extraversion	-.44*	-.44*	.07	.09
Openness to Experience	.05	.00	.12	.01
Agreeableness	-.43	-.13	.37	-.02
Consciousness	-.17	.12	-.27	-.34

* $p < .05$

Pearson's correlations revealed no significant association between Openness to Experience and Accuracy in Old and New Objects, $r = .05$, $p = .85$, and $r = .00$, $p = 1$. Reaction Times also did not reveal any correlation between them in Old and New Correct Objects, r = .12, p = .60, and r = .01, p = .96 (see Table 3). However, a significant negative relationship was found between Extraversion scores in NEO-FFI-20 and accuracy in Old Objects, r = -.44, p = .04, and between the same dimension and accuracy in New Objects, r = -.44, p = .05.

Functional Data

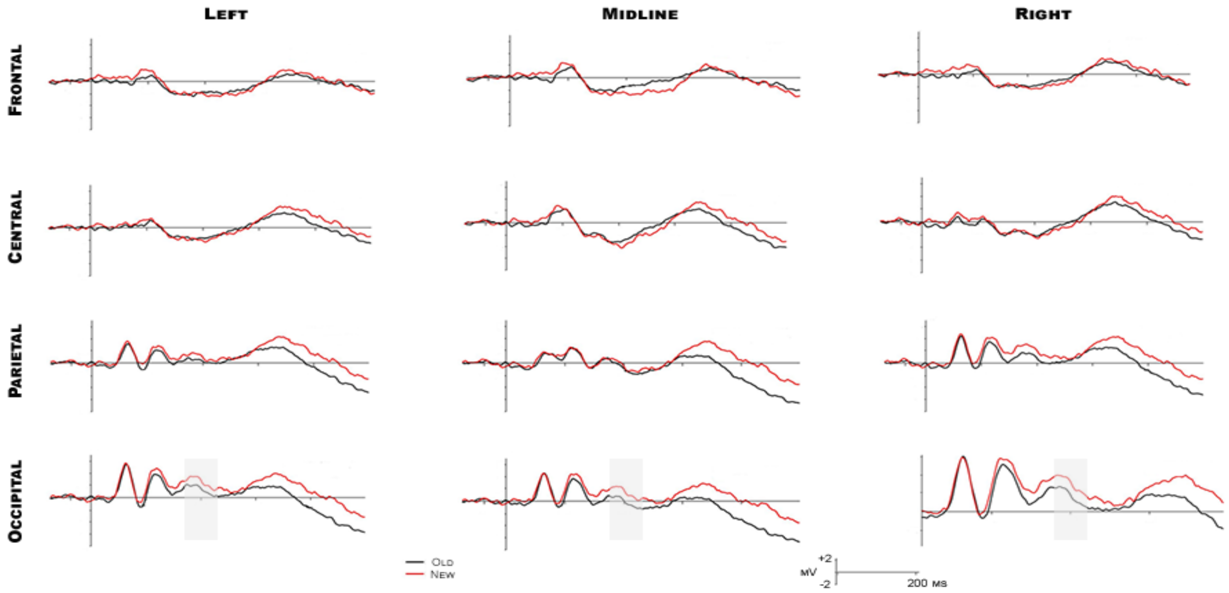

Figure 1. ERP Waveforms for the grand averages across mean amplitude. Effect evidenced in Occipital region.

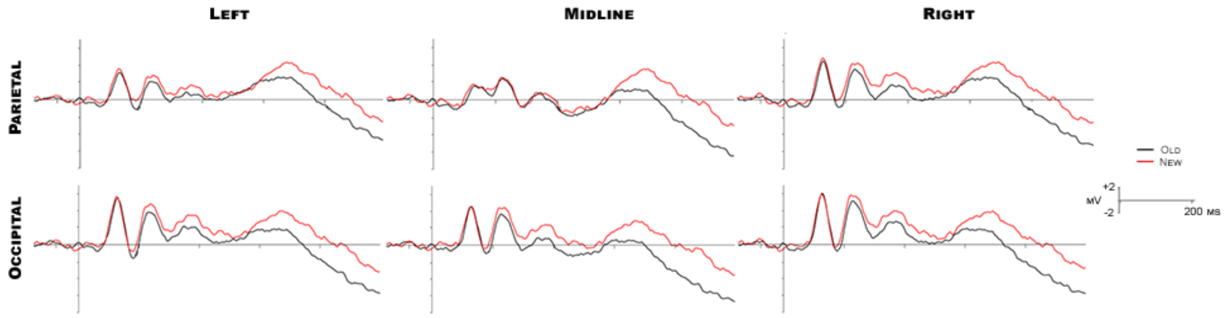

Figure 1. ERP waveforms for the grand averages of P1 and N1 components.

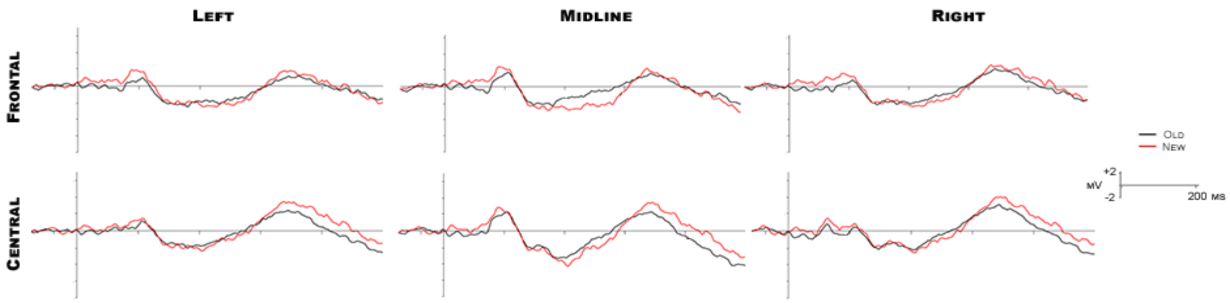

Figure 3. ERP waveforms for the grand averages of the P2 component.

A repeated measures ANOVA with 3 different factors (Object Type, Region and Laterality) showed that, for the mean amplitude in a window of 300-450ms, there was no significant effect in terms of Object Type (Old and New), $F(1,20) = .09$, $p = .77$, $\eta^2 = .01$. In spite of this, there was a statistically significant interaction between Object Type and Region activation, $F(3,60) = 11.06$, $p = .001$. However, pairwise comparisons revealed only a tendency to differ in the occipital region, $p = .09$ (see Figure 1). There was also a significant interaction between Object Type and Laterality activation, $F(2,40) = 3.89$, $p = .03$, $\eta^2 = .16$. Post-hoc tests revealed no pairing differences regarding Object Type. Lastly, there was a significant interaction between the Object Type, Laterality and Region activation, $F(6,120) = 2.24$, $p = .04$, $\eta^2 =.10$. Post-hoc comparisons showed only a tendency to differ in the occipital region of the right hemisphere, with higher amplitude for New Objects when compared to Old ones, $p = .09$.

When addressing the mean amplitude in a time window of 450-700ms, only an interaction between Object Type and Region was significant, $F(3,60) = 7.62$, $p = .01$, $\eta^2 = .28$. However, post-hoc tests revealed no significant differences between the two Object Types.

For the components analysis, a repeated measures ANOVA was again used to compare data. Relative to the P1 component, amplitude showed no significant effect in Object Type, $F(1,20) = .16$, $p = .69$, $\eta^2 = .01$, as well as no effects in latency, $F(1,20) = .00$, $p = .97$, $\eta^2 = .00$ (see Figure 2). Concerning the P2 component, no statistically significant effects of amplitude were found in Object Type, $F(1,20) = .52$, $p = .48$, $\eta^2 = .03$; latency also revealed no effect, $F(1,20) = .61$, $p = .44$, $\eta^2 = .03$ (see Figure 3). Lastly, for N1, no differences were found in amplitude for Object Type, $F(1,20) = .53$, $p = .47$, $\eta^2 = .03$, or in latency, $F(1,20) = .14$, $p = .71$, $\eta^2 = .01$ (see Figure 2). Concerning possible interactions of object type and region or laterality, no other significant effects were found for all three analysed components.

Discussion

According to literature, and to the best of our knowledge, the present study is the first to approach DM using EEG techniques. The exploratory essence of it reflects the importance to fill the gap in what is known, and what has yet to be fully understood. It has been shown that the parahippocampal gyrus plays an important role in successful retrieval of DM, since its activation was evident while participants performed a task where they had to tell facts to faces (Mugikura et al., 2016). However, we still have little information on how brain dynamics work during the execution of a DM task. We lack knowledge of how this process occurs across time. In that matter, we aimed to fill that gap using EEG.

The study focused on distinguishing responses between two Object Types, Old and New. Behavioural data showed us that there was an effect of Object Type on Accuracy rates, with Old Objects leading to lower scores, when compared to New Objects. The same effect was seen in Reaction Times for both Object Types, with Old Objects showing higher Reaction Times when compared to New ones. These differences in performance mean that, for our sample, it was harder to remember the location of an object placed before than to recognize an object being seen for the first time. When assessing performance by gender, women revealed a tendency to have higher Accuracy and lower Reaction Times for New Objects when compared to men. They also had significant shorter Reaction Times for Old Objects, compared to men. These findings support existing literature showing that women outperform men in recognition tasks (Herlitz & Rehnman, 2008), hence the marginal effect for New Objects. However, there is also evidence that men perform better in visual-spatial episodic memory tasks (Herlitz & Rehnman, 2008).

We also intended to address possible connections between personality and performance in the task (Accuracy and Reaction Times of participants for both Old and New Objects). It was expected that Openness to Experience was negatively correlated with accuracy for Old Objects. This was justified by taking into account that plenty of studies demonstrated that there is a positive association between this trait and autobiographic memory in particular, and that link was due in part to an emphasis in experiences of the self (Rasmussen et al., 2010). We know that in DM, focusing attention on oneself, rather than the destination, will pose as an obstacle to achieving the best performance in remembering that same destination afterward (Gopie et al., 2009). No significant correlation between Openness to Experience and performance was found. Therefore, the results could mean that in the case of DM, Openness to Experience does not act as a barrier to recall; it is also not a promoter of recall as it is in autobiographic memory, in which it aids in collecting other types of past experiences (the ones particularly focused on the self and the process).

Despite the outcome, a significant negative correlation was found within the personality traits, between Extraversion and Accuracy. It is possible that this is due to the suggested relationship between Extraversion and Executive Functions in the brain (Campbell, Davalos, McCabe & Troup, 2011), evidenced by similar neurotransmitter processing. In the mentioned study, extraverted individuals revealed different patterns for executive functions, with poorer performance in some tasks that required their use (e.g. set-shifting). This relates to DM in a sense that executive function plays an important part in the encoding of DM information, crucial to later retrieval (El Haj & Miller, 2017). The mentioned study concludes that if the executive function processes are compromised during encoding, recalling will be much more difficult later on.

Regarding functional data, our main aim was to compare differences between Object Type, while also taking into account the electrode's Region and Laterality, so we can better characterize the topographic distribution of the effects at the scalp. No significant effect for each component analysed (P1, P2 and N1) was found in terms of amplitude or latency. It would be interesting in the future to focus more on later components, including the LPN, since it is one of the main components that appear in episodic memory tasks, as well as SM ones (Mecklinger, Rosburg & Johansson, 2016).

Mean amplitudes in windows of 300-450ms and 450-700ms were also analysed comparing the three factors mentioned above. Even though no main effect of Object Type was seen, there was an interaction between Object Type and the Occipital Region in the first time window, meaning that participants overall showed higher mean amplitude (less negativity) in Occipital areas for New Objects in comparison to Old ones in this time window. It also means that overall there was a tendency to show higher negativity for Old Objects, reflecting on higher allocation of resources for the processing of such Objects. The result supports the existing evidence stating that Items seen before versus Items that are being seen for the first time correspond to different types of activation, in which the brain responds with higher negativity (Mecklinger et al., 2016). Furthermore, the fact that this marginal effect is present in the Occipital region supports the claim that the LPN may also play a part in DM dynamics, since it is seen in parietal-occipital areas, around the POz electrode (Mecklinger et al., 2016). However, we may have missed the component due to an early time window (the ERP waveforms in later timings were affected due to the use of the mouse in the task). There was also a significant interaction between the three factors, that revealed a tendency for higher amplitudes in New Objects, in the right side of the same Region. This leads to the conclusion that the effects described above occurred mainly on the right hemisphere of Occipital areas.

Given the obtained data, it is possible to conclude that individuals more easily recognize that they are placing an object for the first time among a group of objects, than accurately recall where they placed another object before. This only emphasizes the importance of the encoding phase when storing memory information: interacting with the Old objects was enough to aid participants in a subsequent task setting them apart from New ones. If perhaps the optimizing conditions were met during encoding (i.e. attention and inhibitory processes), Accuracy for Old Objects could increase. More importantly, we can conclude that individuals not only behave differently, but also their brains respond differently when processing these two Object Types. These changes can be seen in the Occipital region, particularly in the right hemisphere, in which the processing appears to be more extensive (higher negativity) when they are seeing an Object for the second time.

Considering the innovative character of the study, there are a few limitations that should be to be taken into account. Firstly, and mostly because of time constraints, the sample included consisted of an inequivalent number of men and women. Given that we also compared behaviour data between the two, a more proportional sample would be appropriate. Increasing the sample's number would also prove to be more enriching of data, since many of the variables that would also be relevant to the present topic to assess (e.g. errors in New Objects and Old Objects recognized as New), turned out to be too few to properly analyse. Including a rating scale for the confidence of participant's answers would also give some insight on the certainty of their judgments in DM.

Finally, it would be interesting that, in future studies, a task that would allow comparing differences in brain dynamics for SM and DM would most certainly lead to better understanding in how we process them during encoding and recall. An analysis focusing on the principal components that activate in DM would also answer some still underlying questions, such as the possible presence of the LPN component in DM tasks, as it can be seen in SM tasks. The suggested research would make way to uncovering the remaining questions related to DM, contributing to the knowledge of the complex structure that is memory.

References

Baddeley, A. D. (1997). *Human memory: Theory and practice*. Psychology Press.

Berman, A. H., Palmstierna, T., Källmén, H., & Bergman, H. (2007). The self-report Drug Use Disorders Identification Test—Extended (DUDIT-E): reliability, validity, and motivational index. *Journal of Substance Abuse Treatment*, *32*(4), 357-369.

Bertoquini, V., & Pais-Ribeiro, J. L. (2006). Estudo de formas muito reduzidas do Modelo dos Cinco Fatores da Personalidade. *Psychologica*, *43*, 193-210.

Broudeur, M. (2010) Bank of Standardized Stimuli. Retrieved January, 2019.

Campbell, A. M., Davalos, D. B., McCabe, D. P., & Troup, L. J. (2011). Executive functions and extraversion. *Personality and Individual Differences*, *51*(6), 720-725.

Cohen, M. X. (2017). Where does EEG come from and what does it mean?. *Trends in neurosciences*, *40*(4), 208-218.

Davidson, P. S., Drouin, H., Kwan, D., Moscovitch, M., & Rosenbaum, R. S. (2012). Memory as social glue: Close interpersonal relationships in amnesic patients. *Frontiers in psychology*, *3*, 531.

Delorme, A., & Makeig, S. (2004). EEGLAB: an open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of neuroscience methods*, *134*(1), 9-21.

El Haj, M. (2016). Destination memory for self-generated actions. *Aging clinical and experimental research*, *28*(5), 935-941.

El Haj, M., & Miller, R. (2017). Destination memory: The relationship between memory and social cognition. *Psychological research*, *82*(6), 1027-1038.

El Haj, M., Allain, P., & Kessels, R. (2014). The cognitive and neuroanatomical underpinnings of destination memory. *Translational Neuroscience*, *5*(2), 147-151.

El Haj, M., Antoine, P., & Nandrino, J. L. (2017). When deception influences memory: The implication of theory of mind. *Quarterly Journal of Experimental Psychology*, *70*(7), 1166-1173.

Espirito-Santo, H., Pires, C. F., Garcia, I. Q., Daniel, F., Silva, A. G. D., & Fazio, R. L. (2017). Preliminary validation of the Portuguese Edinburgh Handedness Inventory in an adult sample. *Applied Neuropsychology: Adult*, *24*(3), 275-287.

Gopie, N., & MacLeod, C. M. (2009). Destination memory: Stop me if I've told you this before. *Psychological Science*, *20*(12), 1492-1499.

Hayes, S. M., Nadel, L., & Ryan, L. (2007). The effect of scene context on episodic object recognition: parahippocampal cortex mediates memory encoding and retrieval success. *Hippocampus*, *17*(9), 873-889.

Herlitz, A., & Rehnman, J. (2008). Sex differences in episodic memory. *Current Directions in Psychological Science*, *17*(1), 52-56.

Koriat, A., Ben-Zur, H., & Sheffer, D. (1988). Telling the same story twice: Output monitoring and age. *Journal of Memory and Language*, *27*(1), 23-39.

Luck, S. J., & Kappenman, E. S. (Eds.). (2011). *The Oxford handbook of event-related potential components*. Oxford university press.

McCrae, R. R., & Costa Jr, P. T. (2004). A contemplated revision of the NEO Five-Factor Inventory. *Personality and individual differences*, *36*(3), 587-596.

Mecklinger, A., Rosburg, T., & Johansson, M. (2016). Reconstructing the past: The late posterior negativity (LPN) in episodic memory studies. *Neuroscience & Biobehavioural Reviews*, *68*, 621-638.

Mugikura, S., Abe, N., Ito, A., Kawasaki, I., Ueno, A., Takahashi, S., & Fujii, T. (2016). Medial temporal lobe activity associated with the successful retrieval of destination memory. *Experimental brain research*, *234*(1), 95-104.

Oldfield, R. C. (1971). The assessment and analysis of handedness: the Edinburgh inventory. *Neuropsychologia*, *9*(1), 97-113.
Rasmussen, A. S., & Berntsen, D. (2010). Personality traits and autobiographical memory: Openness is positively related to the experience and usage of recollections. *Memory*, *18*(7), 774-786.
Ruiz-Caballero, J. A., & Bermúdez, J. (1995). Neuroticism, mood, and retrieval of negative personal memories. *The Journal of general psychology*, *122*(1), 29-35.
Spreng, R. N. (2013). Examining the role of memory in social cognition. *Frontiers in psychology*, *4*, 437.
Travaglia, A., Bisaz, R., Sweet, E. S., Blitzer, R. D., & Alberini, C. M. (2016). Infantile amnesia reflects a developmental critical period for hippocampal learning. *Nature neuroscience*, *19*(9), 1225.

Anexo

Anexo A – Comissão de Ética da Universidade do Minho

Universidade do Minho

Conselho de Ética

Conselho de Ética - Ciências Sociais e Humanas

Identificação do documento: SECSH 047/2018

Título do projeto: *Exploring brain activity dynamics related to proactive interference and destination memory: An ERP study*

Investigador(a) Responsável: Dr. Diego Pinal Fernandez, Centro de Investigação em Psicologia, Universidade do Minho e Prof Dr Adriana da Conceição Soares Sampaio, Centro de Investigação em Psicologia, Escola de Psicologia, Universidade do Minho

Outros Investigadores: Vasco Ribeiro Ferreira & Diogo Alberto Ferreira Lima, Universidade do Minho

PARECER

O Conselho de Ética analisou o processo relativo ao projeto de investigação acima identificado, intitulado *Exploring brain activity dynamics related to proactive interference and destination memory: An ERP study.*

Os documentos apresentados revelam que o projeto obedece aos requisitos exigidos para as boas práticas na investigação com humanos, em conformidade com as normas nacionais e internacionais que regulam a investigação em Ciências Sociais e Humanas.

Face ao exposto, o Conselho de Ética nada tem a opor à realização do projeto, emitindo o seu parecer favorável.

Braga, 26 de setembro de 2018.

A Presidente

Assinado por : **GRACIETTE TAVARES DIAS**
Num. de Identificação Civil: BI071230157
Data: 2018.10.02 15:17:16 GMT Daylight Time

CARTÃO DE CIDADÃO