Psicológica (2017), 38, 347-363.

Differences in brain activation between the retrieval of specific and categoric autobiographical memories: An EEG study

Laura Ros[*1], José M. Latorre[1], M. José Aguilar[1], Jorge J. Ricarte[1], Alejandro Castillo[2], Andrés Catena[3], and Luis J. Fuentes[2]

[1] *Department of Psychology, Faculty of Medicine, University of Castilla La Mancha, Albacete, Spain.*

[2] *Department of Basic Psychology and Methodology, Faculty of Psychology, University of Murcia, Murcia, Spain.*

[3] *Department of Experimental Psychology, Faculty of Psychology, University of Granada, Granada, Spain.*

Difficulty in retrieving specific autobiographical memories is known as overgeneral autobiographical memory (OGM). OGM has been related with clinical psychopathology (e.g., depression, schizophrenia, etc.). People presenting an OGM style usually recall more repetitive summary-type memories, so-called categoric memories, (e.g., 'each time I saw her') rather than specific memories (events occurring on a specific day whose duration does not exceed 24 hours; e.g., 'the day I met her'). Differences in brain activation in the search phase of the retrieval process of specific and categoric autobiographical memories are examined using EEG techniques. Fourteen younger adults performed an Autobiographical Memory Task. Results show significant differences in the activation between specific and categoric memories mainly in frontal areas during the 2.5 seconds before the memory recovery. Specific memories were associated with an increased activation of the left prefrontal cortex, while brain activation for categoric memories was less intense. These results support the idea that the activation of prefrontal areas is required to facilitate the process of elaborating specific memories.

---

[*] Acknowledgments: This study has been supported by the Regional Government of Castilla La Mancha [Consejería de Educación y Ciencia de Castilla La Mancha, grant PII1I09-0274-8863] and the Ministry of Science and Innovation [Ministerio de Ciencia e Innovación, grant PSI2010-20088]. Corresponding Author: Laura Ros, University of Castilla La Mancha, Faculty of Medicine, Department of Psychology, Avda. Almansa 14, 02006-Albacete (Spain). Phone number: (34) 967 599 200 Ext. 8289. E-mail: Laura.Ros@uclm.es

Autobiographical memory (AM) is the type of memory associated with the retrieval of specific episodes from an individual's past life. AM includes both general knowledge (e.g., "I lived in Spain in 2001"), and specific knowledge referring to a single event experienced at a particular time and place (e.g., "My wedding day was very happy"). This knowledge is arranged in a top-down hierarchical structure: general memories are located at the top and specific memories emerge as an individual moves down the hierarchy (Conway, 2005; Williams et al., 2007). AM is traditionally categorized into three levels of specificity: 1) lifetime periods (abstract knowledge about oneself during a given period of time); 2) general memories, which can be categoric (events repeated during a certain period), or extended (events that last more than one day); and 3) specific memories (events occurring at a particular place and time that last less than one day) (Conway & Pleydell-Pearce, 2000).

In the field of AM, numerous studies have been conducted on the phenomenon known as overgeneral autobiographical memory (OGM; for reviews see Griffith et al., 2012; Williams et al., 2007). OGM refers to the inability to retrieve specific memories, recalling, instead, general memories. A number of studies have identified factors that may be associated with reduced memory specificity. For example, people with emotional disorders (for a review see Williams et al., 2007) or older adults (Piolino et al., 2006; Ros, Latorre, & Serrano, 2010) may find it difficult to retrieve specific memories, increasing the proportion of general memories recalled. They specifically tend to retrieve more categoric memories (general memories referred to events stored in categories such as people, places or activities, for example, "When I had lunch with my husband").

Although most of the work in this field has been focused on a behavioral level, several studies have explored the neural correlates of general and specific memories through functional magnetic resonance imaging (fMRI; Addis, McIntosh, Moscovitch, Crawley, & McAndrews, 2004; Ford, Addis, & Giovanello, 2011; Holland, Addis, & Kensinger, 2011; Levine et al., 2004) and positron emission tomography (PET; Maguire & Mummery, 1999).These studies show an increase of medial and dorsolateral prefrontal activity during specific memory retrieval (Ford et al., 2011; Holland et al., 2011; Levine et al., 2004; Maguire & Mummery, 1999). These results suggest that the prefrontal cortex (PFC) could be essential for the retrieval of specific events. Increased activity in regions of the medial temporal lobes has also been identified (Ford et al., 2011; Holland et al., 2011; Levine et al., 2004; Maguire & Mummery, 1999), as well as associations with areas such as the precuneus (Addis et al., 2004) and retrosplenial cortex (Levine et al., 2004).

These studies differ in the methodology used to generate the autobiographical memories. Some have used interviews prior to the scanner to obtain autobiographical memories and subsequently, these memories were repeated or generated through short titles or words during the scanner session (Addis et al., 2004; Maguire & Mummery, 1999). In the study by Levine et al. (2004), participants recorded daily events for several months and listened to their own recordings at the follow-up session. However, the main problem with this type of procedures is that the use of recordings or cue words provided previously by the participant may eliminate or truncate the search for an autobiographical memory at the time of assessment (Cabeza & St. Jacques, 2007).That is, the use of "personalized" cues could eliminate the search phase of the retrieval process (the initial acquisition of the memory), maintaining only the elaboration phase (remembering the event in detail).The studies conducted by Ford et al. (2011) and Holland et al. (2011) solve this problem by not using cues derived from the participant to obtain the memory. This enables the analysis of the search phase in the retrieval of the memory. Specifically, Ford et al. (2011) used music in the form of popular songs as a cue to generate the memory while Holland et al. (2011) used a series of cue words with a neutral emotional valence. Regardless of whether the cues are “personalized”, other features of the cue can affect the memory process. For example, Uzer, Lee and Brown (2012) found that object cues (e.g., automobile) elicit more direct retrieval than emotional cues (e.g., shy) in autobiographical memory tasks.

Most of these studies have compared specific memories with general memories, without differentiating between categoric and extended memories. OGM, however, seems to be principally related to an increase in categoric memories and a decrease in specific memories (Williams et al., 2007). For this reason, it would be interesting to verify whether the differences found between general and the specific memories are maintained or modified when categoric and specific memories are compared.

Although neuroimaging techniques are accurate in identifying the brain regions that are activated during an activity or cognitive process, they are less accurate in providing information on the exact moment in which cerebral changes take place during a certain process. Nevertheless, despite their lower spatial resolution, EEG techniques present a better temporal resolution capacity (Conway, Pleydell-Pearce, Whitecross, & Sharpe, 2002). Studies using EEG techniques in AM show that the construction of autobiographical memories is associated with increased activation of the left prefrontal cortex (Conway, Pleydell-Pearce, & Whitecross, 2001; Conway, Pleydell-Pearce, Whitecross, & Sharpe, 2003). However, to our knowledge, no studies have been published on differences in brain functioning for categoric and specific memories using these methods.

The main aim of this work is to study the differences in brain activation in the search phase of the retrieval process of specific and categoric memories using EEG techniques, since, as Conway (2005) suggests, the neural differences in the retrieval of general and specific autobiographical memories will be especially evident in the construction phase of the memory retrieval process. In this study, we have used the Autobiographical Memory Test (AMT; Williams & Broadbent, 1986). The AMT is the task most commonly used to assess specificity of autobiographical memories (for a review see Griffith et al., 2012). In the AMT, participants are presented with a series of cue words (usually both positive and negative cue words), for which they are asked to produce a specific memory (e.g., any autobiographical event lasting less than a day). Generally, the memories provided are then coded according to their level of specificity: memories referring to periods measured in seconds, minutes and hours and lasting less than 24 hours are coded as specific memories (e.g., “my wedding day”); memories referring to an extended period are coded as extended memories (e.g., “when I was at school”); and memories referring to a whole class of events generally stored in categories such as persons, places, or activities are coded as categoric memories (e.g. “every argument with my husband”). In this study, we have modified the original task instructions. Thus, in order to generate both categoric and specific autobiographical memories, participants are not provided with guidelines in relation to the type of the autobiographical memory they must produce. This design makes it possible to examine the differences in activity prior to the access to specific or categoric memories.

Williams and Hollan (1981) state that autobiographical memory retrieval is a reiterative process comprising three phases: a) finding a context: establishing criteria to verify the memory and a semantic cue to enable the memory search; b) search: the semantic cue triggers the search for possible memories, accessing first the general event level and then moving down to the specific event level; and c) verification: memories retrieved are compared with the verification criteria. If the criteria are met, the search ends and the information accessed is utilized to generate the memory. If the criteria are not met, the cycle is repeated reiteratively until the memory is retrieved. Several authors suggest this memory process is controlled by central executive processes located in networks in the frontal cortex (Conway, 1996). Thus, deficits in executive functions could limit the successful retrieval of specific memories (Conway & Pleydell-Pearce, 2000). These authors state that the retrieval of specific memories requires, on one hand, processing capacity to set up a retrieval model and to compare it with retrieved information, and on the other, capacity to inhibit information that is irrelevant to the memory being sought. Different studies have found associations between the level of executive function and OGM (e.g., Piolino et al., 2010; Ros et al., 2010; see Sumner 2012 for a revision). For this reason, we specifically expect to find that, in the seconds prior to memory recall, prefrontal regions associated with search and retrieval of memories are more activated during the construction of specific memories than during that of categorical memories.

METHOD

Participants. Fourteen students of Psychology at the University of Murcia participated in this study (13 female; M = 22.07 years, SD = 3.67 years; range =18-29 years). Three participants were subsequently excluded from the analyses: the first one for not remembering any specific memory; the second one for an excess of artifacts in their EEG data after the filtering of EEG data; and the third because their activation patron was significantly different from that of the other participants. Thus, the final sample comprised 11 participants (11 female; M = 22.18 years, SD = 3.60 years; range = 18-29 years). All the participants were right-handers and had no history of psychiatric, neurological, or learning disorders.

This study was approved by the local ethical committee.

Stimuli. A total of 70 words with a high degree of familiarity were selected from the software "Buscapalabras"(B-Pal; Davis & Perea, 2005). B-Pal is the Spanish version of the program N-Watch in English language (Davis, 2005). This program contains 31,491 words in Spanish and is designed to be used in research, allowing to select words according to their familiarity and emotional valence. The words selected show a level of familiarity higher than 5 (1-7), and they were chosen according to their emotional valence: 35 negative words and 35 positive words (see Appendix A).

Autobiographical Memory Task

The task is a version of the original Autobiographical Memory Task (AMT; Williams & Broadbent, 1986), which is commonly used to evaluate OGM. The task consists in presenting cue words to participants who are asked to retrieve an autobiographical memory in response to them. Unlike the original AMT, in this version participants were not instructed to remember specific events. The participants could recall any type of autobiographical memory, that is, something that they had lived or experienced personally.

The participants performed the AMT sitting in front of a 19" screen placed at a distance of 70 cm. First, the instructions were explained clearly and they received four practice cue words to ensure correct understanding. During practice, any possible doubts about the task were resolved. At the end of the practice trials, the task was initiated. In the task, each cue word was presented individually and remained on the screen for 3 seconds. Once participants had retrieved an autobiographical memory from the cue word, they pressed a button on the computer mouse with the index fingers of both hands (bimanual response), in order to control laterality. After pressing the button, they were asked to continue thinking about the memory. After 7.5 seconds, the participant had to describe verbally the event recalled. This was followed by a rest period (see Figure 1). There was no time-limit for participants to describe their memories. Finally, when the participant was ready, they clicked on the mouse and the following cue word appeared on the screen. If the person was unable to generate a memory after 30 seconds, the task went on to the next cue word.

The memories retrieved were recorded with the participants' consent and, subsequently, were coded by two independent researchers on the basis of their specificity. An inter-rater agreement of 85 % was obtained. According to our main objective, only specific and categoric memories were included in the final analysis.

EEG recording

Electroencephalographic data were recorded using Ag/AgCl electrodes located in an elastic electrode cap, at 28 locations according to the International 10-20 system co-ordinates (see Figure 2). All scalp electrodes were referred to mastoids. Vertical and horizontal electro-oculograms (VEOG and HEOG) were recorded from electrodes located below the right eye and at the outer canthi. Data were digitized at a rate of 1000 Hz in all channels and a band pass filter 0.1-20 Hz was applied. Impedance levels were $\leq$ 5 kOhm, and all measurements were referenced to the ground electrode (AFz electrode). Horizontal eye-movements (HEOG) and blinking (VEOG) were controlled and corrected using Least Mean Square algorithm (LMS) implemented in EEGLAB Matlab toolbox available at http://sccn.ucsd.edu/eeglab. After applying this procedure and baseline correction using the whole segment, all trials on which any electrode displayed a shift greater than ± 75 μV were discarded from the analysis as a contaminated artifact. So, the final number of trials was reduced from 183 to 149 specific memories and from 215 to 174 categoric memories. Before statistical analyses of the data, the recording was resampled to 250 Hz.

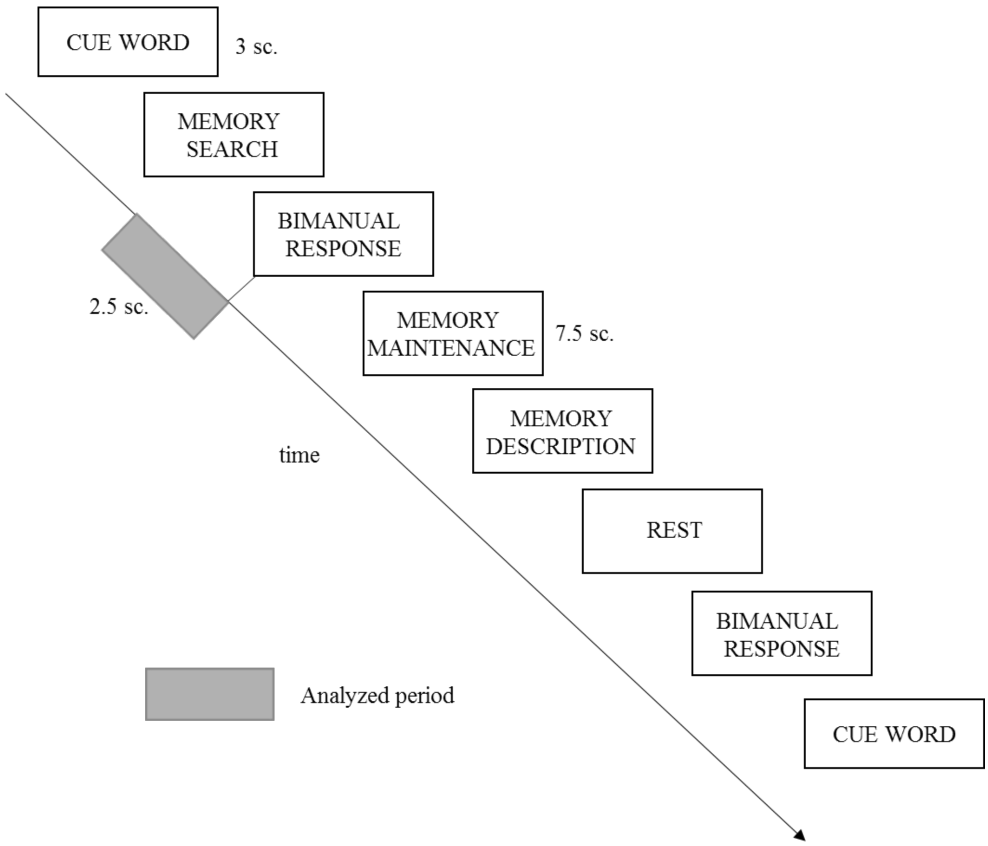


Figure 1. Schema of the experimental procedure.

Taking into account that the memories generated from the different cue words often present different latencies, and considering that the differences in brain activation probably took place some moments before the retrieval of the memory, analyses were performed with the records obtained during the 2.5 seconds prior to the production of the memory, that is, when the participant performed the bimanual response. Grand averages were performed for each epoch in each type of memory and electrode. The mean amplitudes of this period were calculated to perform the different comparisons.

Procedure. The sessions took place individually. Each session lasted approximately two hours. The participant first signed the informed consent form, after which the experimenter placed the cap on the participant's head and verified the correct functioning of the electrodes. The participant then performed the Autobiographical Memory Task. At the end, of the experiment, participants were rewarded with an extra point that could be used to increase their grade in any subject in their degree.

Data analysis. Statistical analysis was conducted using the SPSS 19.0 software. First, Wilcoxon signed-rank tests were performed to determine whether there were any significant differences in the latency time and in the number of memories according to memory type (specific vs categorical).

For the EEG data analyses, several electrodes were clustered based on their location. There were thus six clusters: FL (Frontal region – Left hemisphere): Fp1, AF3, F3, F5, F7; FR (Frontal region – Right hemisphere): Fp2, AF4, F4, F6, F8; CL (Central region – Left hemisphere): FC5, C3, CP5; CR (Central region – Right hemisphere): FC6, C4, CP6; PL (Posterior region – Left hemisphere): P3, PO7, O1; PR (Posterior region – Right hemisphere): P4, PO8, O2. A repeated measures ANOVA (6 electrode regions x 2 type of memories) and post hoc Bonferroni tests were performed to analyze whether there were significant differences in brain activation depending on memory type. Effect sizes were also estimated using partial squared eta (η^2) coefficients.

RESULTS

Behavioral data

Using the Wilcoxon signed-rank test, no significant differences were found ($p > .05$) between the number of specific and categorical memories retrieved by the subjects during the task (M = 13.55, SD = 6.55, and M = 15.82, SD = 10.08, respectively) nor in the latencies for each memory type (M = 9.07 seconds, SD = 5.36 in specific memories, and M = 7.72 seconds, SD = 3.97 in categorical memories).

Analyzing the number of specific and categorical separately for each cue word type (positive vs negative), we found that negative cue words generated more specific memories than positive cue words (*M* = 5.17, *SD* = 3.92, and *M* = 8.38, *SD* = 3.38, for positive and negative cues respectively; *Z* = -2.67, *p* = .008), but we found no statistical differences in the number of categoric memories obtained from positive and negative cue words (*M* = 8.60, *SD* = 5.73, and *M* = 7.21, *SD* = 4.52, for positive and negative cues respectively; *Z* = -.1.85, *p* = .064).

EEG data

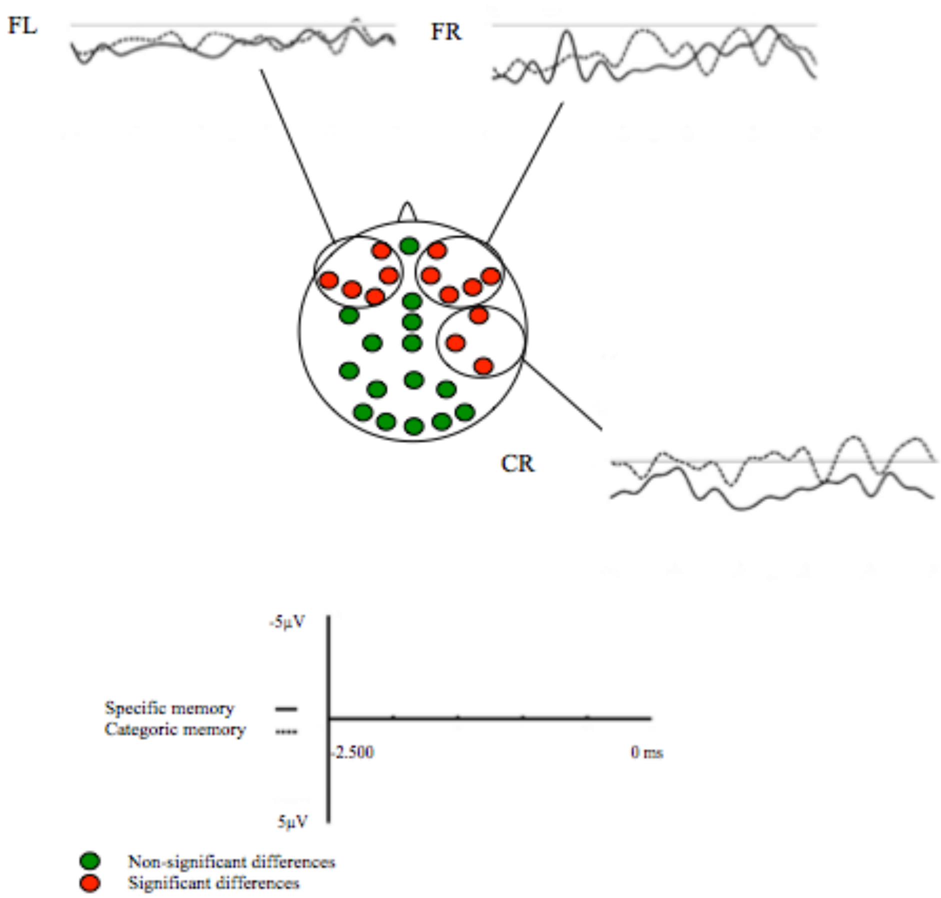
The results show significant differences in the activation of the different memory types, mainly in both frontal regions and in the right central region during 2.5 seconds prior to the retrieval of memory (bimanual response) (see Table 1). A repeated measures ANOVA (Memory [2] x Region [6]) shows a significant Memory effect ($F(1,10) = 6.13$; $p= .033$; partial $\eta^2= 0.38$). Post hoc Bonferroni test results found higher positive activation for specific memories than for categoric memories (*B*= 0.69; *p*= .033).

Table 1. Means and (standard deviations) for the amplitude of the EEG signal in each cerebral region according to the type of memory.

Amplitude μv	Specific M (SD)	Categorical M (SD)
FL	1.06 (1.09)	-0.0003 (1.15)
FR	1.40 (1.33)	0.16 (1.2)
CL	1.17 (1.66)	0.08 (1.18)
CR	0.89 (1.21)	0.28 (1.10)
PL	0.29 (0.64)	0.18 (0.36)
PR	0.07 (0.57)	-0.01 (0.54)

Note. FL = Frontal region – Left hemisphere; FR = Frontal region – Right hemisphere; CL = Central region – Left hemisphere; CR = Central region – Right hemisphere; PL = Posterior region – Left hemisphere; PR = Posterior region – Right hemisphere.

Finally, although the interaction Memory x Region was not statistically significant ($F(5,50) = 1.45$; $p= .247$; partial $\eta^2= 0.13$), post hoc Bonferroni test results suggest that there is a higher positive activation for specific memories than for categoric memories in the following regions: FL ($B= 1.05$; $p= .020$), FR ($B= 0.1.24$; $p= .032$), and CR ($B= 0.61$; $p= .011$) (See Figure 2).



Note. FL = Frontal region – Left hemisphere; FR = Frontal region – Right hemisphere; CR = Central region – Right hemisphere.

Figure 2. Location of electrode groups and significant differences between categoric and specific memories during access to autobiographical memory.

DISCUSSION

Although most of the studies examining the neural correlates of AM have focused on the comparison between specific and general memories, various studies indicate that OGM relates mainly to an increase in categoric memories and a decrease in specific memories, and this pattern of remembering would influence the development and maintenance of emotional disorders (Williams et al., 2007). For this reason, this work has focused specifically on assessing the changes in the EEG pattern during the access to specific and categoric memories. The results show that there are significant differences in the activation of the frontal and central right pericranial regions depending on the type of autobiographical memory recalled in the 2.5 second prior to the memory retrieval.

During the 2.5 seconds prior to memory retrieval, the specific memories seem to be associated with a higher cerebral activation than categoric memories. These differences are significant in both hemispheres of the frontal regions and in the central right pericranial region. These results seem to be in agreement with those found by Holland et al. (2011) in which the frontal activation is associated with the specificity of memories. Although autobiographical memory also involves temporal and parietal networks associated with episodic memory, the prefrontal processing seems to be more associated with personal information and the self (King, Hartley, Spiers, Maguire, & Burgess, 2005; Maguire & Frith, 2003; Piefke, Weiss, Zilles, Markowitsch, & Fink, 2003a; Summerfield, Hassabis, & Maguire, 2009). Thus, the frontal areas would be critical in the access to specific information and would allow the person to locate the memories and retrieve them in their temporal context. In this sense, the prefrontal cortex activity would be related to memory search and generative retrieval of AM (Botzung, Denkova, Ciuciu, Scheiber, & Manning, 2008; Cabeza & St. Jacques, 2007; St. Jacques, Kragel, & Rubin, 2011).

Several studies have also found associations between a greater activation of the left prefrontal cortex and the retrieval of experiences, and these associations have been considered a reflection of the so-called working self (Conway et al., 2001; Conway et al., 2003; Daselaar et al., 2008). For instance, St. Jacques et al. (2011) found an association between prefrontal cortex and the autobiographical self-referential retrieval, search processes and goal-directed processes. Andrews-Hanna, Reidler, Sepulcre, Poulin and Buckner (2010) also found that prefrontal areas were involved in the making of self-decisions. In the same line, Magno and Allan (2007) found activity changes within areas of the medial prefrontal lobe and medial posterior cingulate when the retrieval was associated with the self. Gilboa

(2004) suggests that the left prefrontal area is more associated with the processing of self-referential information. According to Conway & Pleydell-Pearce (2000), the working self is part of the control processes of the working memory and is related to the management and modification of the representations of the concepts about oneself in memory (self-schemas). Thus, individuals with high and low working memory abilities differ primarily on tasks that require self-initiated processing (Unsworth, 2009). Spillers and Unsworth (2011) suggest that people with low working memory capacity do not use contextual information to retrieve memories and show less control of their memory episodic search processes, using self-generated retrieval cues.

Numerous studies have demonstrated the activation of the prefrontal region in working memory tasks (Bor, Cumming, Scott, & Owen, 2004; Bor, Duncan, Wiseman, & Owen, 2003; D´Esposito et al., 1998; Owen, 2000). This could explain the differences in the activation of the frontal pericranial regions between specific and categoric memories, due to the cognitive effort performed by the subject, which is assumed to be higher in the access to specific memories. In fact, several authors have found a negative relationship between OGM and executive functioning (Dalgleish et al., 2007; Ros et al, 2010). Piolino et al. (2004) related the left sided prefrontal cortex activity to the complexity and effortfulness of tasks. According to Williams (2006), implementation of the executive processes is required to activate the search pattern of specific memories in AM. Thus, the executive processes are necessary to inhibit aspects irrelevant to the memory search and that can cause interference in the search for a specific memory (Dalgleish et al., 2007). In the same line, Ros et al. (2010) showed that working memory capacity is related positively to specific memories and negatively to categoric memories. In this regard, may be necessary to isolate the effort made by retrieval.

The most important limitation of this study is that all participants included in the final sample were women. One male participant was dropped from the analysis because his activation patron was significantly different from that of the other participants. In this sense, several studies have demonstrated a negative correlation between brain activity in women and men in cognitive tasks (Bell, Wilson, Wilma, Dave, & Silverstone, 2006; Jausovec & Jausovec, 2010; Piefke, Weiss, Zilles, Markowitsch, & Fink, 2003b). Nevertheless, this makes it difficult to generalize these results to a male population.

In summary, this study shows that, in the search and construction phase of the AM, memory specificity is associated with increased activation of the left prefrontal cortex during the 2.5 seconds prior to memory recall, in comparison to categoric memories. Future studies are needed to examine whether these differences in the construction of the memory continue in the maintenance phase. In this sense, some authors suggest that during the maintenance of the memory the posterior regions (temporal and occipital) are activated because they provide the sensory and perceptual information for the memory (Cabeza & St. Jacques, 2007). Given that one of the main differences between specific and categoric memories is the existence of more sensory information in specific memories, the activation of these posterior areas would be expected to be greater in the case of specific events.

RESUMEN

Diferencias en la activación cerebral en la recuperación de recuerdos autobiográficos específicos y categóricos: Un estudio con EEG. El recuerdo autobiográfico sobregeneralizado (OGM) es la dificultad para recuperar recuerdos autobiográficos específicos. La sobregeneralización está relacionada con la psicopatología clínica (e.g., depresión, esquizofrenia, etc.). Las personas que presentan un estilo de recuerdo sobregeneralizado normalmente recuerdan eventos de tipo repetitivo, denominados recuerdos categóricos (e.g., "cada vez que la veía"), en lugar de recuerdos específicos (eventos ocurridos en un día concreto cuya duración no excede las 24 horas; e.g., "el día que la conocí"). Utilizando técnicas de EEG, se examinan las diferencias existentes en la activación cerebral en la fase de búsqueda del proceso de recuperación de recuerdos autobiográficos específicos y categóricos. Catorce participantes llevaron a cabo una Tarea de Recuerdo Autobiográfico. Los resultados muestran diferencias significativas entre recuerdos específicos y categóricos en la activación cerebral, principalmente en las áreas frontales durante los 2.5 segundos previos a la recuperación del recuerdo. Concretamente, los recuerdos específicos están asociados a un aumento de la activación del córtex prefrontal izquierdo, mientras que la activación cerebral es menos intensa y más difusa en los recuerdos categóricos. Estos resultados apoyan la idea de que es necesaria la activación de las áreas prefrontales para facilitar el proceso de elaboración de los recuerdos específicos.

REFERENCES

Addis, D. R., McIntosh, A. R., Moscovitch, M., Crawley, A. P., & McAndrews, M. P. (2004). Characterizing spatial and temporal features of autobiographicalmemory retrieval networks: A partial least squares approach. *Neuroimage, 23,* 1460–1471. doi:10.1016/j.neuroimage.2004.08.007

Andrews-Hanna, J. R., Reidler, J. S., Sepulcre, J., Poulin, R., & Buckner, R. L. (2010). Functional-anatomic fractionation of the brain's default network. *Neuron, 65*, 550-562. doi: 10.1016/j.neuron.2010.02.005

Bell, E. C., Willson, M. C., Wilman, A. H., Dave, S., & Silverstone, P. H. (2006). Males and females differ in brain activation during cognitive tasks. *Neuroimage, 30*, 529-538. doi:10.1016/j.neuroimage.2005.09.049

Bor, D., Cumming, N., Scott, C. E. M., & Owen, A. M. (2004). Prefrontal cortical involvement in encoding strategies, independent of stimulus modality. *European Journal of Neuroscience, 19,* 3365-3370.doi: 10.1111/j.1460-9568.2004.03438.x

Bor, D., Duncan, J., Wiseman, R. J., & Owen, A. M. (2003). Encoding strategies dissociate prefrontal activity from working memory demand. *Neuron, 37,* 361-367.doi: 10.1016/S0896-6273(02)01171-6

Botzung, A., Denkova, E., Ciuciu, P., Scheiber, C., & Manning, L. (2008). The neural bases of the constructive nature of autobiographical memories studied with a self-paced fMRI design. *Memory, 16*, 351-363. doi: 10.1080/09658210801931222

Cabeza, R., & St. Jacques, P. (2007). Functional neuroimaging of autobiographical memory. *Trends in Cognitive Sciences, 11*, 219-227. doi: 10.1016/j.tics.2007.02.005

Conway, M. A. (1996). Failures of autobiographical remembering. In D. Herrmann, M. Johnson, C. McEvoy, C. Hertzog, & P. Hertel (Eds.), *Basic and applied memory: Theory in context*. (pp. 295-315). Hillsdale, NJ: Erlbaum.

Conway, M. A. (2005). Memory and the Self. *Journal of Memory and Language, 53*, 594-628. doi: 10.1016/j.jml.2005.08.005

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memoriesin the self-memory system. *Psychological Review, 107*, 261–288.doi: 10.1037/0033-295X.107.2.261

Conway, M. A., Pleydell-Pearce, C. W., & Whitecross, S. (2001). The neuroanatomy of autobiographical memory: A slow cortical potential study of autobiographical memory retrieval. *Journal of Memory and Language, 45*, 493-524. doi: 10.1006/jmla.2001.2781

Conway, M. A., Pleydell-Pearce, C. W., Whitecross, S., & Sharpe, H. (2002). Brain imaging autobiographical memory. *The Psychology of Learning and Motivation, 41*, 229-263. doi: 10.1016/S0079-7421(02)80008-1

Conway, M. A., Pleydell-Pearce, C. W., Whitecross, S., & Sharpe, H. (2003). Neurophysiological correlates of memory for experienced and imagined events. *Neuropsychologia, 41*, 334-340. doi: 10.1016/S0028-3932(02)00165-3

Dalgleish, T., Williams, J. M. G., Golden, A. M., Perkins, N., Barrett, L. F., Barnard, P. J., et al. (2007). Reduced specificity of autobiographical memory and depression: The role of executive control. *Journal of Experimental Psychology: General, 136*, 23-42. doi: 10.1037/0096-3445.136.1.23

Daselaar, S. M., Rice, H. J., Greenberg, D. L., Cabeza, R., LaBar, K. S., & Rubin, D. (2008). The spatiotemporal dynamics of autobiographical memory: Neural correlates of recall, emotional intensity, and reliving. *Cerebral Cortex, 18,* 217-229. doi: 10.1093/cercor/bhm048

Davis, C. J. (2005). N-Watch: A program for deriving neighbourhood size and other psycholinguistic statistics. *Behavior Research Methods, 37*, 65-70.

Davis, C.J., & Perea, M. (2005). A program for deriving orthographic and phonological neighborhood statistics and other psycholinguistic indices in Spanish. *Behavior Research Methods, 37,* 665-671.

D´Esposito, M., Aguirre, G. K., Zarahn, E., Ballard, D., Shin, R. K., & Lease, J. (1998). Functional MRI studies of spatial and nonspatial working memory. *Cognitive Brain Research, 7,* 1-13. doi: 10.1016/S0926-6410(98)00004-4

Ford, J. H., Addis, D. R., & Giovanello, K. S. (2011). Differential neural activity during search of specific and general autobiographical memories elicited by musical cues. *Neuropsychologia, 49,* 2514-2526. doi: 10.1016/j.neuropsychologia.2011.04.032

Gilboa, A. (2004). Autobiographical and episodic memory - one and the same? Evidence from prefrontal activation in neuroimaging studies. *Neuropsychologia, 42*, 1336-1349. doi: 10.1016/j.neuropsychologia.2004.02.014

Griffith, J. W., Sumner, J. A., Raes, F., Barnhofer, T., Debeer, E., & Hermans, D. (2012). Current psychometric and methodological issues in the measurement of overgeneral autobiographical memory. *Journal of Behavior Therapy and Experimental Psychiatry, 43,* S21-31. doi:10.1016/j.jbtep.2011.05.008

Holland, A. C., Addis, D. R., & Kensinger, E. A. (2011). The neural correlates of specific versus general autobiographical memory construction and elaboration. *Neurospychologia, 49*, 3164-3177. doi: 10.1016/j.neuropsychologia.2011.07.015

Jausovec, N., & Jausovec, K. (2010). Resting brain activity: Differences between genders. *Neuropsychologia, 48,* 3918-3925. doi:10.1016/j.neuropsychologia.2010.09.020

King, J. A., Hartley, T., Spiers, H. J., Maguire, E. A., & Burgess, N. (2005). Anterior prefrontal involvement in episodic retrieval reflects contextual interference. *Neuroimage, 28*, 256-267. doi:10.1016/j.neuroimage.2005.05.057

Levine, B., Turner, G. R., Tisserand, D., Hevenor, S. J., Graham, S. J., & McIntosh, A. R. (2004). The functional neuroanatomy of episodic and semantic autobiographical remembering: A prospective functional MRI study. *Journal of Cognitive Neuroscience, 16,* 1633–1646. doi: 10.1162/0898929042568587

Magno, E., & Allan, K. (2007). Self-reference during explicit memory retrieval: An event-related potential analysis. *Psychological Science, 18*, 672-677. doi: 10.1111/j.1467-9280.2007.01957.x

Maguire, E. A. & Frith, C. D. (2003). Aging affects the engagement of the hippocampus during autobiographical memory retrieval. *Brain, 126*, 1511-1523. doi: 10.1093/brain/awg157

Maguire, E. A., & Mummery, C. J. (1999). Differential modulation of a common memory retrieval network revealed by positron emission tomography. *Hippocampus, 9,* 54–61. doi: 10.1002/(SICI)1098-1063(1999)9:1<54::AID-HIPO6>3.0.CO;2-O

Owen, A. M. (2000). The role of the lateral frontal cortex in mnemonic processing: The contribution of functional neuroimaging. *Experimental Brain Research, 133*, 44-43. doi: 10.1007/s002210000398

Piefke, M., Weiss, P. H., Zilles, K., Markowitsch, H. J., & Fink, G. R. (2003a). Differential remoteness and emotional tone modulate the neural correlates of autobiographical memory. *Brain, 126*, 650-668. doi: 10.1093/brain/awg064

Piefke, M., Weiss, P.H., Zilles, K., Markowitsch, H. J., & Fink, G. R. (2003b). Gender differences in the functional neuroanatomy of emotional episodic autobiographical memory. *Human Brain Mapping, 24*, 313-324. doi: 10.1002/hbm.20092

Piolino, P., Coste, C., Martinelli, P., Macé, A., Quinette, P., Guillery-Girard, B., et al. (2010). Reduced specificity of autobiographical memory and aging: Do the executive and feature binding functions of working memory have a role? *Neuropsychologia, 48,* 429-440. doi: 10.1016/j.neuropsychologia.2009.09.035

Piolino, P., Desgranges, B., Clarys, D., Guillery-Girard, B., Taconnat, L., Isingrini, M., et al. (2006). Autobiographical memory, autonoetic consciousness, and selfperspective in aging. *Psychology and Aging, 21*, 510-525. doi: 10.1037/0882-7974.21.3.510

Piolino, P., Giffard-Quillon, G., Desgranges, B., Chetelat, G., Baron, J. C., & Eustache, F. (2004). Re-experiencing old memories via hippocampus: A PET study of autobiographical memory. *Neuroimage, 22*, 1371-1383. doi: 10.1016/j.neuroimage.2004.02.025

Ros, L., Latorre, J. M., & Serrano, J. P. (2010). Working memory capacity and overgeneral autobiographical memory in young and older Adults. *Aging, Neuropsychology, and Cognition, 17*, 89-107. doi: 10.1080/13825580903042650

Spillers, G. J. & Unsworth, N. (2011). Variation in working memory capacity and temporal-contextual retrieval from episodic memory. *Journal of Experimental Psychology, 37*, 1532-1539. doi: 10.1037/a0024852

St. Jacques, P. L., Kragel, P. A., & Rubin, D. C. (2011). Dynamic neural networks supporting memory retrieval. *Neuroimage, 57*, 608-616. doi: 10.1016/j.neuroimage.2011.04.039

Sumner, J. A. (2012). The mechanisms underlying overgeneral autobiographical memory: An evaluative review of evidence for the CaR-FA-X model. *Clinical Psychology Review, 32*, 34-48. doi: 10.1016/j.cpr.2011.10.003

Summerfield, J. J., Hassabis, D., & Maguire, E. A. (2009). Cortical midline involvement in autobiographical memory. *Neuroimage, 44,* 1188-1200. doi: 10.1016/j.neuroimage.2008.09.033

Unsworth, N. (2009). Individual differences in self-initiated processing at encoding and retrieval: A latent variable analysis. *The Quarterly Journal of Experimental Psychology, 62*, 257-266. doi:10.1080/17470210802373092

Uzer, T., Lee, P. J., & Brown, N. R. (2012). On the prevalence of directly retrieved autobiographical memories. *Journal of Experimental Psychology, 38*, 1296-1308. doi: 10.1037/a0028142

Williams, J. M. G. (2006). Capture and rumination, functional avoidance, and executive control (CARFAX): The processes that underlie overgeneral memory. *Cognition & Emotion, 20*, 548-568. doi: 10.1080/02699930500450465

Williams, J. M. G., Barnhofer, T., Crane, C., Hermans, D., Raes, F., Watkins, E., & Dalgleish, T. (2007). Autobiographical memory specificity and emotional disorder. *Psychological Bulletin, 133,* 122-148. doi: 10.1037/0033-2909.133.1.122

Williams, J. M. G. & Broadbent, K. (1986). Autobiographical memory in suicide attempters. *Journal of Anormal Psychology, 95,* 144-149. doi: 10.1037/0021-843X.95.2.144

Williams, M. D., & Hollan, J. D. (1981). The process of retrieval from very long-term memory. *Cognitive Science, 5*, 87-119. doi: 10.1207/s15516709cog0502_1

APPENDIX A

Nouns used in the Autobiographical Memory Task.

Positive Words

Safety, Energy, Patience, Friend, Success, Easiness, Smile, Health, Strength, Happiness, Affection, Joy, Confidence, Favor, Union, Fondness, Rest, Justice, Beauty, Party, Love, Laughter, Excitement, Help, Solidarity, Play, Gift, Life, Goodness, Encouragement, Will, Wellbeing, Friendliness, Amusement, Peace.

Negative Words

Boredom, Nightmare, Rival, Blood, Separation, Affliction, Effort, Accident, Discouragement, Impatience, Failure, Fight, Pain, Loneliness, Injustice, Insult, Obligation, Fear, Selfishness, Rage, Attack, Illness, Laziness, Suspicion, Violence, Contempt, Difficulty, Tiredness, Injury, Lie, Misfortune, Depression, Accused, Death, Wickedness.

(Manuscript received: 20 April 2016; accepted: 21 March 2017)