Aging & Mental Health, 2015
Vol. 19, No. 10, 940–946, http://dx.doi.org/10.1080/13607863.2014.995590

Routledge
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Improvement of encoding and retrieval in normal and pathological aging with word–picture paradigm

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(*Received 23 July 2014; accepted 28 November 2014*)

Objectives: During the aging process, there is a progressive deficit in the encoding of new information and its retrieval. Different strategies are used in order to maintain, optimize or diminish these deficits in people with and without dementia. One of the classic techniques is paired-associate learning (PAL), which is based on improving the encoding of memories, but it has yet to be used to its full potential in people with dementia. In this study, our aim is to corroborate the importance of PAL tasks as instrumental tools for creating contextual cues, during both the encoding and retrieval phases of memory. Additionally, we aim to identify the most effective form of presenting the related items.
Method: Pairs of stimuli were shown to healthy elderly people and to patients with moderate and mild Alzheimer's disease. The encoding conditions were as follows: word/word, picture/picture, picture/word, and word/picture.
Results: Associative cued recall of the second item in the pair shows that retrieval is higher for the word/picture condition in the two groups of patients with dementia when compared to the other conditions, while word/word is the least effective in all cases.
Conclusion: These results confirm that PAL is an effective tool for creating contextual cues during both the encoding and retrieval phases in people with dementia when the items are presented using the word/picture condition. In this way, the encoding and retrieval deficit can be reduced in these people.

Keywords: Alzheimer; paired-associate learning; cued recall

Introduction

The aging process is inevitably associated with memory loss, which becomes particularly relevant when it is associated with the onset of the neuropathological impairment that occurs in Alzheimer's disease (AD). Many authors have attributed these memory losses to a severe deficit in the development of new associations, thereby making it difficult for older people to combine different memory units into one cohesive unit. AD patients record poor semantic encoding of to-be-learned information, a deficit in the ability to evaluate semantic relationships, and are no longer able to discriminate between two related concepts. This is called the associative deficit hypothesis (Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003). Paired-associate learning (PAL) tasks provide an ideal paradigm for assessing associative memory. This task involves the cued recall of semantically related word pairs, and it is particularly effective in detecting early and preclinical AD (Pike, Rowe, Moss, & Savage, 2008).

In other studies, PAL tasks are also used to understand memorial familiarity for pictures and words in patients with mild cognitive impairment (MCI) and AD. O'Connor and Ally (2010) applied paired-associate stimuli to three groups of participants (healthy elderly people, patients with MCI, and AD patients), varying the mode of incidental presentation of the stimulus: WW (word–word), WP (word–picture), PW (picture–word), and PP (picture–picture). These researchers were able to confirm the benefit produced by the images regarding the words in the subsequent recognition test. However, PAL tasks are used at other times as a strategy for improving encoding processes with semantic contextual cues in people with MCI and AD. Although it has traditionally been posited that patients with dementia of Alzheimer type (DAT) do not improve their memories through the use of cued recall (Monti et al., 1996), other scholars have recently argued that people with MCI and AD may benefit from the use of semantic cues for retrieving words (Carlesimo, Perri, & Caltagirone, 2011). Yet these patients improved only with the introduction of strong cues during both the encoding and retrieval phases (Adam et al., 2007; Johnson, Schmitz, Asthana, Gluck, & Myers, 2008; O'Donnell, Pietrzak, Ellis, Snyder, & Maruff, 2011; Pike et al., 2008). People with moderate and mild dementia are a particular profile of patients in which PAL tasks may have substantial benefits because in these people the rate of memory loss is not elevated. They still maintain the ability to learn and retain some information and skills despite their memory difficulties (Clare & Woods, 2004; Grober, Hall, Sanders, & Lipton, 2008; Grober, Sanders, Hall, & Lipton, 2010). This is particularly true when PAL tasks are used successfully for the generation of associations between the names and faces of people (Brum, Forlenza, & Yassuda, 2009; Tardif & Simard, 2011; Wenisch et al., 2007) or the relationship between faces and moods (Werheid, McDonald, Simmons-Stern, Ally, & Budson, 2011). We contend that

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this procedure may also be useful in the encoding and subsequent recall of the association of concepts. In this line of research, there are data indicating that patients with moderate and mild dementia may improve their performance in episodic memory tasks that provide supportive conditions during both the encoding and retrieval phases. It appears necessary to provide retrieval cues in order to obtain the effects of supportive encoding conditions. In particular, this occurs when PAL tasks are used as contextual cues, where the first item of the pair is presented as a cue for the retrieval of the associated item. The cued recall technique aims to enhance spontaneous free recall through the presentation of semantic cues (the first item of the pair), to help both the encoding and the retrieval of the second item in the pair, which is the target of the test. This technique is thought to minimize the effect of impaired memory in cued recall tasks related to moderate dementia and AD (Ivanoiu et al., 2005).

However, at the same time it is reported that these patients are not capable of creating a strong semantic association between pairs of words. Patients with moderate dementia and AD have the so-called encoding profile, meaning they can semantically encode verbal materials; however, they do so in a less comprehensive and insufficient manner. Hence it is considered that pairs of words are not the best way of showing the items in order to create contextual cues and, unfortunately, only a few studies are focused on the benefits of PAL tasks as contextual cues during both the encoding and retrieval phases in people with moderate dementia and AD (Tounsi et al., 1999). One possible strategy for improving the procedure may be based on the picture superiority effect. This effect is a consistent empirical finding showing that stimuli presented as pictures are better remembered than stimuli presented as words. This effect has been confirmed in healthy elderly people (Ally et al., 2008), as well as in patients with MCI and AD (Ally, Gold, & Budson, 2009). The explanation for this is that the pictures are more distinctive because of their visual features. Accordingly, in order to corroborate the importance of PAL tasks as effective tools for creating contextual cues during both the encoding and retrieval phases, we introduced pictures in the procedure for pair-associated learning. We sought to determine the best way of presenting the related items showing the combined items under the form of WW, WP, PW, and PP. We have used the overall procedure given by O´Connor and Ally (2010). Nevertheless, in order to convert it into a more natural procedure, we asked the participants to expressly encode the associated pairs they are presented, with our aim being for them to carry out a guided free recall test, instead of a recognition task that is less common in everyday life. We believed that related items in the pair with a visual component, namely, those associations that incorporated an image (WP, PW, PP), could increase both encoding and retrieval performance in cued recall tasks in healthy elderly people, and in patients with moderate and mild AD dementia, when compared to those composed solely of words (WW). According to these considerations, we formulate our first hypothesis, whereby WP, PW, and PP associations have a higher recall rate than WW associations. The second hypothesis is that WP and PW associations have a higher recall rate than WW and PP associations, as these conditions have a double verbal−visual component. In this hierarchical model, as explained by Zeelenberg and Pecher (2003), the conceptual level represented by an image and the lexical and substantive level represented by a word are interconnected, and one activates the other. In this way, the activation of a semantic field (word) allows the image to be contextualized in a semantic network, where less interference is produced during the encoding and retrieval phases. The third hypothesis is that all the above phenomena not only occur in healthy elderly people, but also in people with moderate and mild dementia. This is because patients with pathological aging still maintain the ability to benefit from contextual cues, even in advanced stages of the disease (Adam et al., 2007; Johnson et al., 2008; O'Donnell et al., 2011; Pike et al., 2008).

Methods

Participants

Sixty-four elderly people participated in the study. These participants formed three distinct groups: 22 patients/residents at the State Reference Center for people with Alzheimer's disease formed the group of moderate dementia (NINCDS-ADRDA, National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association), diagnosed with mild AD and with a Global Deterioration Scale (GDS) = 4 by a physician at the center. The mean age was 80.43 years (SD = 12.930; age range of 46−90) with a Mini Mental State Exam (MMSE weighted by age and years of schooling, Folstein, Folstein, & McHugh, 1975) mean of 15.57 (SD = 3.673; range 10−20). The second group was composed of 21 patients at the State Reference Center for people with AD, diagnosed by a physician at the center as suffering from moderate dementia (NINCDS-ADRDA) with a GDS = 2−3. The mean age was 82.94 years (SD = 12.407; range 47−100), with a MMSE mean of 23.31 (SD = 2.414; range 21−25). The families of both groups of patients provided informed consent for their participation in the study. In accordance with the center's ethical protocol, a report was sent out to each patient's immediate family or guardian for them to sign and return. The third group was made up of 21 people living in nursing homes who did not have a neurodegenerative pathology, and who were classified as healthy older adults by a physician at the home. The mean age of the group was 80.12 (SD = 7.415; range 63−91), with a MMSE mean of 27.29 (SD = 2.024; range 24−30). The participants provided their informed consent to participate in the study. We found differences between the three groups in terms of their MMSE values [F (2, 59) = 8.668, p <.001]. No alcohol or drug abuse was found in the participants' medical history, and anamnesis was performed. The study discarded those participants with any depressive symptoms, measured by the Beck Depression Inventory (Beck, Steer, & Brown, 1996, value > 10), as well as those people with medical backgrounds involving

Table 1. Demographic data.

	Groups					
	Healthy older adults		Mild dementia		AD patients	
	Means	SD	Means	SD	Means	SD
Years of education	7.35	3.14	6.06	2.95	6.00	3.63
Age	80.12	7.41	82.94	12.40	80.43	12.93
MMSE	27.29	2.02	23.31	2.41	15.57	3.67
Men	24%	38%	27%			
Women	76%	62%	73%			

problems in their communication system or in their ability to read. We confirmed that there were no differences across the three groups in terms of educational level, years of schooling, age, or gender distribution (see Table 1).

Materials

We used a database of 60 pairs of words, from which we randomly obtained 4 lists of 15 pairs for each participant (e.g., eagle−mountain, wine−cheese). As a rule, we used a low average association index for all pairs of stimuli, then selected and matched them based on the factors 'frequency of use' and 'level of association' from the normative study by Fernandez, Diez, Alonso, and Beato, (2004). Four types of combinations were formed from each list of stimuli: WW, WP, PW, and PP, where the pictures for the WP, PW, and PP combinations were obtained by transforming the actual words in the pairs into their corresponding Snodgrass drawings (Snodgrass & Vanderwart, 1980; see Figure 1).

Each pair was shown in four forms (WW, WP, PW, and PP), and presented in PAL tasks, where the first item in the pair (left) favored the encoding and retrieval of the second item in the pair (right). All stimuli were presented using the E-Prime experimental program with 25% in size, displayed on a 15″ screen with a resolution of 1024 × 768, and placed at a distance of 48″ from the participants. The words were displayed in black against a white background, measuring 3 cm in size.

Procedure

Each participant completed four 30-minute sessions, with each one corresponding to a type of encoding (WW, WP, PW, and PP). The sequence of the sessions was randomized for each participant; the sessions were held one week apart from each other. The individual sessions were divided into two phases: one of learning and one of retrieval. In the learning phase, 15 pairs of stimuli were displayed one at a time on the computer screen for 10 seconds, with each one being interspersed with a fixation point displayed in the center of the screen for 1 second. Participants read the words or named the visual stimuli aloud. There was enough time between the two phases to inform the participants, through instructions presented on the computer screen, that the learning task had been completed and that the retrieval task was about to begin. During the retrieval task, the first item in the pair was displayed on the screen, and the participants were asked to remember the associated item. Stimulus presentation in the recovery phase was not subject to a time limit. Scores were obtained assigning 1 point for each correct retrieval, 0.5 for each retrieval by means of a phonetic prompt using the 'errorless learning' method (Hopper et al., 2012), and 0 for each retrieval either not performed or performed incorrectly. We thus obtained the recall rate for each participant and for each learning condition performed with PAL tasks.

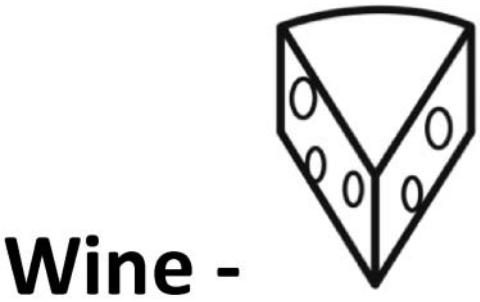

Figure 1. Combination formed by a word and a picture.

Statistical analysis

With the results obtained, we performed an ANOVA 4 (encoding type: WW, WP, PW, and PP) × 3 (group: healthy older adults, moderate dementia, and mild dementia AD patients), with the factor-type encoding as within-subject, and the factor group as inter-subject. Based on the factors recording significant differences ($p < 0.05$), we conducted Bonferroni *post hoc* tests on the comparison of pairs.

Results

Table 2 presents the descriptive data. The multivariate contrast recorded significant differences due to the main encoding factor [$F(3, 59) = 44.525$, $p < .001$]. As regards the *post hoc* tests (see Figure 2), the WP encoding obtained significantly higher recall rates when compared to the WW encoding ($p < .001$), PW ($p < .001$), and PP ($p < .001$). The WW encoding had a significantly lower performance with respect to PW ($p < .001$) and PP

Table 2. Group recall rates of the second item in the pair in cued recall PAL tasks.

	Groups							
	Healthy older adults		Mild dementia		AD patients		Means	
	Means	SD	Means	SD	Means	SD	Means	SD
Word/word	9.64	2.49	7.33	2.67	5.15	1.88	7.34	2.97
Word/picture	11.92	2.37	10.38	2.49	7.75	2.06	9.98	2.87
Picture/word	9.59	2.41	9.11	2.71	6.25	2.53	8.28	2.93
Picture/picture	11.00	2.67	8.50	3.02	6.45	2.26	8.61	3.22
Means	10.54	2.48	8.83	2.72	6.40	2.18		

($p < .001$). Finally, the PW and PP encodings recorded no significant differences.

We also found significant differences due to the group factor [F (2, 61) = 19.55, $p < .001$]. The group of healthy older adults recorded a significantly higher success rate when compared to the groups of patients with moderate dementia ($p < .005$) and with mild dementia ($p < .001$). Furthermore, patients with moderate dementia recorded a significantly higher success rate compared to mild dementia patients ($p < .001$).

Finally, we found significant interaction effects between the two factors [F (6, 120) = 2.254, $p < .001$]. The group of patients with mild AD dementia manifested a significantly lower performance in the four types of encoding (see Figure 2) in comparison to patients with moderate dementia and the healthy older adults group ($p < .001$). The group of patients with moderate dementia recorded a significantly lower performance in WW ($p < .001$) and PP ($p < .001$) compared to the healthy older adults, but was not different in the WP and PW encoding types.

If we consider the performance of each group in the different types of encoding, we find that the three groups performed better in the WP encoding condition compared to WW (all groups, $p < .001$) and PW (all groups, $p < .001$). The WP encoding condition produced more efficient recall with respect to PP solely in the groups with dementia (moderate dementia, $p < .001$; mild dementia, $p < .005$). The PP encoding condition proved to be beneficial for all three groups when compared to WW (all groups, $p < .005$), but only beneficial for the group of healthy older adults when compared to PW ($p < .001$). Furthermore, the PP condition did not generate any advantages in the group with mild or moderate dementia when compared to WP and PW. The PW encoding condition was beneficial only for the group with moderate dementia when it was compared with WW ($p < .001$), while it did not produce any significant advantage for the groups with mild dementia and the healthy older adults.

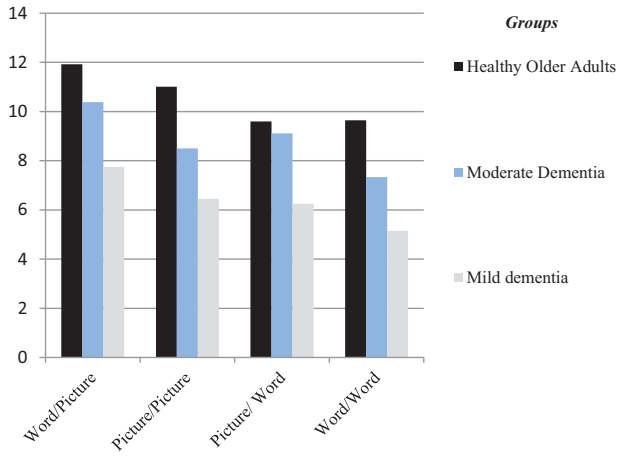

Figure 2. Group recall rates in PAL tasks for different encoding types.

Conclusions

In general, as we assumed in our first hypothesis, there is an improvement in the recall of information when a picture is part of the associated pair, as compared to the use solely of written words. This is a further finding to support recent studies that argue that visual recall cues help to restore the memory of learnt associations. Nevertheless, we have shown here that the effective use of the advantageous properties of images during the encoding and retrieval processes requires the pictures to be presented in a particular way.

The most efficient encoding type is when the first item in the pair is a word and the second item in the pair is a picture. This is because images are a privileged category of stimuli that enrich the verbal material that is being learned, by means of double encoding via both semantic/conceptual and visual perception. Images favor information encoding processes, allowing for deeper processing, generating less interference in memory, and thereby favoring the discrimination between items (Curran & Doyle, 2011). The familiarity of the associations studied is greatly enhanced if a word (the first item in the pair) previously activates a semantic network that will more closely connect a visual representation (Ally & Budson, 2007). In other words, the word generates an activation effect that allows for a quicker and easier retrieval of the picture studied (Zeelenberg & Pecher, 2003) because the word previously activates a semantic network helping to closely converge the memory with its visual representation.

As expected, the groups varied significantly depending on the degree of cognitive impairment. People with mild AD recorded a significantly lower performance in all circumstances with respect to the other groups, but the group of patients with moderate dementia appears to have

made notable use of the benefits of the WP and PW paradigm, being no different to the healthy older adults group. We may conclude, therefore, that the semantic and visual coding represented by the WP and PW paradigm is particularly useful for creating an optimal cued recall response in people with moderate dementia. This is relevant mainly because it is believed that only images favor both the coding and retrieval phases of learned material, and stimulate the memory in people with dementia (Ally, McKeever, Waring, & Budson, 2009). The results here would appear to defend the idea that the items need to be shown in a double encoding form (WP paradigm) to people with moderate dementia in order to create an effective contextual cue. The use of images to stimulate memory in older people is well known, being practiced in the majority of nursing homes around the world. It has traditionally been considered that images are more efficiently processed through both verbal and visual encoding channels (Paivio, 1991; Sadoski & Paivio, 2004), as they have a dual sensory-semantic system of representation and encoding (Nelson, McEvoy, & Schreiber, 2004), which thereby enriches the information of the stimulus (Ally et al., 2009). This association activates categorization processes, generating a clearer and more precise conceptual representation of the information that ultimately suffers from less interference. Consequently, this increases the likelihood of success in the memory phase (Cherry, Hawley, Jackson, & Volaufova, 2008). Nevertheless, images help to create more effective encoding and improve semantic processes, generating a deeper encoding of information that provides a familiar structure of items that are easily managed by memory (Lovseth & Atchley, 2010). Accordingly, the interferences generated when new information is acquired and retrieved are significantly reduced, ensuring an organization that promotes the associations between the items, giving the information greater stability during the learning process, and establishing a connection between previous and recent learning (Campos, Pérez-Fabello, & Camino, 2010).

According to some authors, words together with visual stimuli activate a pre-semantic level that interacts with episodic and semantic systems, favoring perceptual priming, which is relatively well preserved in patients with dementia (Garrard, Lambon Ralph, Patterson, Pratt, & Hodges, 2005; Heindel, Salmon, & Butters, 1990; Job & Tenconi, 2002). The formation of perceptual priming involves the words and images in a similar process, because the overlapping of codes allows for access to a common conceptual memory storage area (Kazmerski & Friedman, 1997), thereby generating deeper associations and improving memory retrieval.

Nonetheless, double verbal−visual encoding is not always the core reason for the improvement in the test's performance. When we have followed the sequence of picture followed by a word, only those patients with a moderate impairment benefit from the use of these recall cues compared to the use of written words. Curiously enough, the PW format tends to be used in many nursing homes where an open display is made of a drawing followed by its lexical association (e.g., a flower and the name of the patient 'Rose'). Yet this format does not seems to be of any great use to people with severe cognitive impairment or to older adults without such impairment. The pictures themselves do not trigger the appropriate semantic network, often interfering with the activation of the word that appears in second place. This means that we cannot fully confirm our second hypothesis on the similar effectiveness of the PW and WP formats in people with dementia.

These findings differ from those reported by O´Connor and Ally (2010) for a recognition task. These scholars found that two pictures constituted the condition that best assisted recognition, with word−face (WF) pairs recording the worst performance. Their findings seem to suggest that the degree of perceptive familiarity and distinctiveness of the picture shown in the test is the key aspect for recognition. In our study, the PP condition is an effective procedure for healthy elderly people, but not for those with cognitive impairment. Healthy people are able to use the distinctiveness of the pictures, whereas those with cognitive impairment cannot use this resource. The impaired management of spatial memories has recently been reported by Toepper et al. (2014).

Finally, we consider that this line of research should be examined further in order to contribute to the development of neuropsychological rehabilitation techniques designed to help healthy elderly adults and those with neurodegenerative diseases maintain the ability to memorize new information and/or develop procedures to restore lost learning. Among others, we believe that this line of research can be used in conjunction with other cognitive techniques based on the so-called picture superiority effect (Allyet al., 2009; Curran & Doyle, 2011) and cued recall PAL tasks (Boudreaux, Cherry, Elliott, & Hicks, 2011; Cherry et al., 2012), where the encoding and retrieval of information can be enhanced in healthy elderly people (Laeng, Øvervoll, & Ole Steinsvik, 2007) and people with mild dementia (Ally et al., 2008; Cabeza, Anderson, Locantore, & McIntosh, 2002) or AD (Hussey, Smolinsky, Piryatinsky, Budson, & Ally, 2011; Joubert et al., 2010). Addressing the importance of double encoding as regards the distinctiveness of pictures would require enlarging the sample used. It would also be expedient to consider the role of interference in the absence of wholly positive results in certain conditions involving the use of pictures. Finally, there is a need to confirm the influence that institutionalization has on these results in comparison with non-institutionalized individuals.

Acknowledgements

We would like to express gratitude to the CRE Alzheimer's Salamanca-IMSERSO; Government of Spain for the contract for research collaboration between The Neurosciences Institute of Castile and Leon and The National Reference Centre of Alzheimer Disease.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Spanish Ministry of Science and Innovation [grant number MICINN, # BFU2010-17754].

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