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How emotional pictures influence visuospatial binding in short-term memory in ageing and Alzheimer's disease?

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ABSTRACT

The present study examines the prediction that emotion can facilitate short-term memory. Nevertheless, emotion also recruits attention to process information, thereby disrupting short-term memory when tasks involve high attentional resources. In this way, we aimed to determine whether there is a differential influence of emotional information on short-term memory in ageing and Alzheimer's disease (AD). Fourteen patients with mild AD, 14 healthy older participants (NC), and 14 younger adults (YA) performed two tasks. In the first task, involving visual short-term memory, participants were asked to remember a picture among four different pictures (negative or neutral) following a brief delay. The second task, a binding memory task, required the recognition by participants of a picture according to its spatial location. The attentional cost involved was higher than for the first task. The pattern of results showed that visual memory performance was better for negative stimuli than for neutral ones, irrespective of the group. In contrast, binding memory performance was essentially poorer for the location of negative pictures in the NC group, and for the location of both negative and neutral stimuli in the AD group, in comparison to the YA group. Taken together, these results show that emotion has beneficial effects on visual short-term memory in ageing and AD. In contrast, emotion does not improve their performances in the binding condition.

1. Introduction

It is widely known that individuals remember emotional information better than non-emotional information (Hamman, 2009; Kensinger, 2009). While this emotional enhancement is relatively well-preserved throughout life span (Kessinger, 2008), it is clearly impaired in Alzheimer's disease (*e.g.,* Abriquesta-Gomez, Bueno, Oliveira, & Bertolucci, 2002; Hiroaki, 2002; Kensinger, Anderson, Growdon, & Corkin, 2004). However, studies focus essentially on long-term memory for emotional items, and little behavioural data is available on short-term memory in healthy and unhealthy ageing. This is of particular interest, since emotional enhancement may be linked to neural mechanisms involving the amygdala and prefrontal cortices, which intervene in the encoding of information (Kesinger & Corkin, 2004).

A number of studies have investigated visual short-term memory for emotional items in young, healthy adults (see Jackson, Wolf, Johnston, Raymond, & Linden, 2008; Kesinger & Corkin, 2003), but the methodology differed from one study to another, and conflicting results were obtained. In addition, differences in attentional load allocated during the tasks could have an important impact on short-term memory performance. Many researchers have taken an interest in short-term memory for emotional items throughout life. Langeslag and Van Strien (2009) noted a spared emotional effect, and Mikels, Larkin, Reuter-Lorenz, and Carstensen (2005) pointed to a positivity effect bias, based on the fact that older adults tended to recognise positive stimuli better than negative ones. This pattern of results was consistent with the concept of emotional long-term memory (Charles & Carstensen, 2004; Davidson & Glisky, 2002; Denburg, Buchanan, Tranel, & Adolphs, 2003; Kensinger, Brierley, Medford, Growdon, & Corkin, 2002; Kesinger, Krendl, & Corkin, 2006; May, Rahhal, Berry, & Leighton, 2005; Otani, Libkuman, Widner, & Graves, 2007), suggesting an automatic arousing enhancement in ageing, even if the effect associated with valence was somewhat impaired (see Kessinger, 2008).

Studies investigating short-term memory in Alzheimer's disease (AD) are rare. If one refers to the findings relating to long-term memory, one might expect no emotional effect in short-term memory. Nevertheless, interestingly, Rosenbaum, Furey, Horwitz, and Grady (2008) reported greater cerebral connectivity between prefrontal cortices and the amygdala during a short-term memory task in AD. Based on these results, the authors suggested that AD patients may rely on compensatory emotional mechanisms for this task.

In the present study, we investigated the effects of negative emotion on visuospatial binding in short-term memory in ageing

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and AD. The binding mechanism allows for integrating information from multiple domains into a unified representation (Baddeley, 2000), and involves a cost in terms of attentional resources (Elsley & Parmentier, 2009; Fougnie & Marois, 2009; Wheeler & Treisman, 2002). Research on short-term memory binding is now well-explored in ageing. Some authors indicate that healthy older adults have more difficulties than younger adults regarding object-location binding (Cowan, Naveh-Benjamin, Kilb, & Saults, 2006), and suggest that this decrease in performance could be linked to hippocampal dysfunction (Mitchell, Johnson, Raye, & D'Esposito, 2000). However, other authors show that younger and older groups have comparable performances regarding the storing of integrated object representations for the binding of an object's surface features, such as colour and shape (Brockmole, Parra, Della Sala, & Logie, 2008; Brown & Brockmole, 2010; Parra, Abrahams, Logie, & Della Sala, 2008; Parra et al., 2009). Research on AD clearly shows that the disease impairs the mechanisms enabling the maintenance of integrated features of objects in short-term memory (Parra, Abrahams, Logie, & Della Sala, 2010; Parra et al., 2009).

However, whether or not emotional processing prevents or improves feature binding in short-term memory is a phenomenon which has received comparatively little attention. Emotionally salient stimuli have an attentional cost, as they tend to capture the attention more than neutral stimuli (Olofsson, Nordin, Sequeira, & Polich, 2008; Schupp, Flaisch, Stockburger, & Junghöfer, 2006; Schupp et al., 2004). Although this emotional bias is automatic and facilitates rapid processing of emotion, it may decrease the resources available for more voluntary control of attention performance (*e.g.,* Johnson et al., 2005; MacKay et al., 2004; McKenna & Sharma, 2004). If emotional stimuli automatically demand more attention, our prediction is that they may disrupt the binding processes by which the unification of item and location takes place in short-term memory (Mather et al., 2006; Mitchell, Mather, Johnson, Raye, & Greene, 2006). Therefore, the goal of the present study was to examine how attentional resources allocated to feature binding in short-term memory might interfere with the emotional content during ageing and in the course of AD.

In the present experiment, the performances of younger healthy adults, older healthy adults, and patients with AD were assessed during short-term memory tasks, in which participants were required to remember either only the picture (control condition) or the location of the picture (binding condition). Our aim was to bring to light any difference in effect between the control condition and the binding condition. We believed that negative pictures would require more attention and would probably reinforce encoding and remembering following a short delay. Therefore, we hypothesised that it would be easier for young and healthy controls to remember emotional items than neutral items in the control condition. We retained the same hypothesis for AD patients, in view of our hypothesis that compensatory mechanisms would intervene following a short delay.

In addition, and on the basis of Mather's hypothesis (Mather et al., 2006), it could be expected that attentional cost for emotional items would disrupt the processes necessary for memory binding. In other words, the binding condition, which incurs an attentional cost, could be expected to interfere with the processing of emotional items.

In comparison with young adults, older adults appear to focus more on emotional items (Comblain, D'Argembeau, Van der Linden, & Aldenhoff, 2004), attributing greater attention resources to emotional stimuli. Therefore, our prediction was that healthy older participants would exhibit reduced memory for negative information compared to neutral information. In addition, as object-location binding seems to become more fragile with age, we expected to observe a general drop in performance in healthy older adults as compared with younger adults. In the case of Alzheimer's disease, if binding abilities were impaired, there would be a similar decrease in performance for both negative and neutral information.

2. Methods

2.1. Participants

2.1.1. Selection and participant characteristics

The study included 42 participants: 14 patients diagnosed with mild Alzheimer's disease (10 women and four men; mean age: 80.92 ± 3.6 years; mean education: 10.5 ± 2.17 years), 14 healthy age-matched controls (NC) (nine women and five men; mean age: 78.35 ± 4.1 years; mean education: 10.71 ± 2.16 years), and 14 healthy young controls (YA) (10 women and four men; mean age: 27.07 ± 2.17; mean education: 12 ± 0 years). There was no statistically significant age difference between the AD and NC groups.

The AD patients participating in the present study were recruited from the neurology department of Saint-Etienne University Hospital; all had been diagnosed with AD by a neurologist in accordance with the criteria developed by the National Institute of Neurological and Communicative Disorders (NINCDS), and the Stroke and Alzheimer's disease and Related Disorders Association (ADRDA; McKhann et al., 1984). Extensive neuropsychological assessment, brain imaging using magnetic resonance techniques or computerised tomography (CT) scanning, and biological tests (thyroid-stimulating hormone levels, creatinine, vitamin B12, calcemia, and TPHA-VDRL syphilis serology, all of which were within normal limits) were performed in order to confirm the diagnosis of AD. Patients in the AD group had mild dementia, defined by a score of $\geqslant$23 on the Mini-Mental State Examination scale (MMSE; Folstein, Folstein, & McHugh, 1975), with the onset of the disorder going back to a maximum of 3 years.

The two groups of healthy participants were recruited among the parents of staff members or from outside the neurology department. All had a MMSE score of at least 27 and were not suffering from dementia. Any ongoing psychiatric or neurological disorders were considered to be exclusion criteria.

2.1.2. General neuropsychological assessment

The three groups differed significantly in terms of their MMSE score ($F[2, 39] = 51.13$; $p < .0001$). Analyses revealed a significant difference between AD and healthy older controls (AD: mean ± SD = 24.4 ± 1.6; NC: mean ± SD = 27.6 ± 1.5; $p < .0001$), and between healthy older controls and younger adults (YC: mean ± SD = 29.7 ± 0.7; $p < .001$).

In addition, all participants were assessed in their mood states in order to minimise the influence of variables such as depression and anxiety. Depressive mood was assessed using the depression questionnaire QD_2A (Pichot et al., 1984), and anxiety by the Questionnaire Anxiety Scale (Goldberg, Bridges, Duncan-Jones, & Grayson, 1988). Overall, none of participants met the criteria for anxiety and depression, and the groups did not differ with respect to these parameters (see Table 1).

Patients with AD were the only participants to undergo a complete standardised examination by a neuropsychologist. Episodic memory was assessed using the "*16-item free and cued recall test*" (RL/RI 16-items) (Van der Linden, Coyette, Poitrenaud, & Gremem, 2004), a test of episodic memory similar to the Free and Cued Selective Reminding test (FCSRT) (Grober, Buschke, Crystal, Bang, & Dresner, 1988). After controlled learning had been completed for all 16-items, there were three consecutive test trials consisting of free recall, followed by cued recall for the items not retrieved during the free recall. The sum of free and cued recall for each trial was called total recall. The sum of free and cued