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Musical and verbal memory in Alzheimer's disease: A study of long-term and short-term memory

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ABSTRACT

Musical memory was tested in Alzheimer patients and in healthy older adults using long-term and short-term memory tasks. Long-term memory (LTM) was tested with a recognition procedure using unfamiliar melodies. Short-term memory (STM) was evaluated with same/different judgment tasks on short series of notes. Musical memory was compared to verbal memory using a task that used pseudowords (LTM) or syllables (STM). Results indicated impaired musical memory in AD patients relative to healthy controls. The deficit was found for both long-term and short-term memory. Furthermore, it was of the same magnitude for both musical and verbal domains whether tested with short-term or long-term memory tasks. No correlation was found between musical and verbal LTM. However, there was a significant correlation between verbal and musical STM in AD participants and healthy older adults, which suggests that the two domains may share common mechanisms.

1. Introduction

In recent years, music has been a focus of interest in cognitive neuroscience. Music is present in all cultures, increases the quality of life of individuals and contributes to social cohesion. Its role, universality, and omnipresence (Trainor, 2008) have motivated the empirical investigation of the way musical elements are processed and memorized, and have supported the development of sophisticated models of music cognition (for a review, Peretz & Zatorre, 2005). Most of these models focus on the cognitive components that are involved in the perception and production of music but some of these components have implications for musical memory. For example, Peretz and Coltheart (2003) propose the existence of a musical lexicon, a registry of familiar musical phrases that would also be involved in the formation of new musical representations. Damage to the musical lexicon would produce deficits in the retrieval of familiar melodies stored in the lexicon but could also create difficulties in forming new traces in long-term memory (LTM). Cognitive models of short-term memory (STM) have proposed the existence of a tonal loop, a dedicated short-term storage component for musical material (Berz, 1995; Marin & Perry, 1999). In addition, neurobehavioral findings support the existence of dedicated brain areas for memorizing musical material. Structures in the right temporal lobe would play an important role in musical LTM (Samson & Zatorre, 1992), particularly when memorizing less familiar melodies (Peretz & Zatorre, 2005) whereas short-term memorization of musical stimuli would engage the right auditory cortex (Zatorre, Evans, & Meyer, 1994; Zatorre & Samson, 1991) and frontal regions (Zatorre et al., 1994).

Surprisingly, little is known regarding the effect of brain-related memory disorders on musical memory (but see Samson & Peretz, 2005). The impact of Alzheimer's disease (AD), the most prevalent memory disorder, on musical memory is sparsely documented. Tasks used to assess memory in AD typically involve verbal or visuo-spatial material and only a few studies have examined musical memory. Assessment of musical memory in AD is relevant for many reasons. First, music contributes to the well-being of many older persons (Cohen, Bailey, & Nilsson, 2002). Also, music therapy is often used with AD patients and seems to bring some benefits in the management of their symptoms (Koger & Brotons, 2000). Finally, investigating the breakdown of musical memory in AD and how this compares to verbal memory disorder may contribute to our understanding of the neuroscience of musical memory.

We are aware of only three studies that speak about whether LTM for musical material is impaired in AD. Quoniam et al. (2003) tested AD patients with an incidental learning paradigm in which participants were told to listen to unfamiliar melodies that were played 1, 5 or 10 times without being instructed that they would be tested later for their memory of the melodies. When tested later with a recognition procedure, the authors found impaired memory in AD patients. Halpern and O'Connor (2000) also evaluated incidental learning of unfamiliar melodies in AD. In this study, participants were asked to rate the speed of eight unfamiliar musical excerpts and were later tested for their memory of the excerpts in a surprise recognition task. The results indicated no

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significant difference between AD patients and healthy older adults in the recognition test. However, the two groups performed near chance level. This floor effect makes it difficult to interpret the absence of a group difference in the study. Finally, Bartlett, Halpern, and Dowling (1995) compared the recognition of unfamiliar melodies in AD and in normal aging with participants receiving intentional learning instructions this time. Results indicated no difference between patients and healthy controls, but again both groups performed at a low level. Thus, only one study reported impaired musical memory in AD while the other two studies reported unimpaired performance; however, the two studies that did not find any impairment were limited by a near-floor effect which could have masked the presence of any group differences.

The data on the STM capacities of AD persons for musical material is even scarcer than that on LTM. White and Murphy (1998) tested STM with a same/different judgment task following presentation of four and five binary-tone sequences. They found musical STM deficit in both very mild AD and mild AD. In contrast, Kurylo, Corkin, Allard, Zatorre, and Growdon (1993) reported no deficit in AD patients in a completely different paradigm. Participants were asked to identify the tone with a pitch change in a succession of three- to five-tone melodies.

Thus, a first question this paper addresses is whether memory for musical material is impaired in AD when performance is not limited by floor effects. Our study measures both STM and LTM for musical material as most memory models identify them as independent storage systems. It is thus relevant to know whether they are both impaired in AD. Models of memory from the late sixties and early seventies (Atkinson & Shiffrin, 1968) proposed that STM and LTM have a sequential relationship, information having to transit from STM before accessing LTM. However, findings from experimental psychology and neuropsychology challenged this sequential view (for example, Basso, Spinnler, Vallar, & Zanobio, 1982; Warrington, Logue, & Pratt, 1971; Warrington & Shallice, 1969) and subsequent models proposed a more complex organization that did not include an obligation for information to transit through STM prior to accessing LTM (Baddeley, 1986; Baddeley & Hitch, 1974; Shallice & Warrington, 1970). Finally, proceduralist views propose that material determines to a large extent the way information is memorized irrespective of whether this is tested with STM or LTM tasks (Craik & Lockhart, 1972; Crowder, 1989, 1993; Foster & Jelicic, 1999). Proceduralist models suggest that memory and information processing are supported by the same cognitive and cerebral components. In this view, memory for verbal or musical material would depend on the components that are involved in perceiving and producing verbal and musical information. Though our study was not designed to test those models, they do justify our use of STM and LTM tasks. A proceduralist approach predicts that STM and LTM musical memory should be associated in AD patients whereas the non-sequential view would predict the reverse (that is, lack of an association). A sequential view would predict that while LTM deficits might occur in isolation in AD, STM deficits should always be accompanied by LTM deficits.

A second goal of this study was to compare memory for musical material to that of verbal material in AD patients. This is important because there is a debate regarding the independence of music and language processing. Some models of music processing support the notion of a distinction between memory for verbal and memory for musical information (for example, Peretz & Coltheart, 2003). This view is based on the observation of amusic patients who, congenitally or after having acquired cerebral lesions, exhibit a deficit in musical memory while verbal memory is spared (Peretz, 1996). It also relies on data indicating that musical memory predominantly involves the right hemisphere (Peretz & Zatorre, 2005; Samson & Zatorre, 1992; Zatorre, 2001; Zatorre & Krumhansl, 2002), whereas verbal memory predominantly recruits the left hemisphere (Burton, Locasto, Krebs-Noble, & Gullapalli, 2005; Cabeza & Nyberg, 2000). Other models hold that music is not 'special' and that musical and verbal domains share some of their mechanisms (Anvari, Trainor, Woodside, & Levy, 2002; Patel, Peretz, Tramo, & Labreque, 1998) and rely on similar brain regions (Jentschke, Koelsch, Sallat, & Friederici, 2008; Koelsch, Gunter, Wittfoth, & Sammler, 2005). One example of shared components is syntax processing that would recruit similar mechanisms and brain regions in the musical and language domains (Koelsch et al., 2002, 2005; Patel, 2003, 2005).

Investigating the effect of a brain-related memory disorder (AD in the present study) on musical and verbal memory could contribute to the issue regarding the independence of music and language processing. Although it is generally assumed that the memory deficit of AD covers various types of materials, the impairment can be material-specific in mild AD (Baddeley, Della Salla, & Spinnler, 1991; Becker, Lopez, & Wess, 1992). It has been suggested that in the early stage of the disease, some patients exhibit neuropathological anomalies in one hemisphere predominantly, rather than bi-laterally (Fisher et al., 1996, 1997), and this could lead to material-specific impairment. Music and language seem ideally suited to test the domain-specificity of impairment in early AD as they share a number of interesting characteristics: both can be presented auditorily, involve a temporal structure and are governed by rules. If musical and verbal memory are processed independently, patients whose degenerative process first strikes regions of the right hemisphere, which is proposed to be engaged in musical processing, should exhibit musical memory deficits, whereas those whose pathology first strikes regions of the left hemisphere, engaged in verbal processing, should exhibit verbal memory deficits. This should result in different degrees of impairment when comparing memory for musical and memory for verbal material and in a weak association between the two materials. The only study that compared memory for musical and verbal materials in AD was that of White and Murphy (1998). They compared a two-tone recognition musical STM task with two verbal STM tasks: digit span forward and digit span backward. Relative to healthy older adults, very mild and mild AD showed both musical STM deficit and verbal STM deficit as measured by the digit span backward. Based on these results, the authors concluded that verbal and musical memory decline in a similar way in AD. However, the musical and verbal conditions were not ideally matched in that study. Recall was used in the verbal task whereas recognition was used in the musical task. Moreover, the digit span backward requires manipulation of information, a process that was not involved in the recognition of musical sequences. The use of digits, a material that is high in lexical and semantic content, does not compare well with the use of musical notes.

In summary, little is known regarding musical memory in AD. Studies on musical LTM and STM reported conflicting results. Furthermore, no study has compared verbal and musical LTM in AD. Only one study reported equivalent deficits in the STM for musical and verbal materials in AD, but the study did not use equivalent conditions across materials. Thus, the objectives of the present study were to evaluate the presence of musical memory deficits in AD using both LTM and STM tasks and to compare it to memory for verbal material. Our goal was to use musical and verbal memory versions that would be as comparable as possible, thus allowing optimal conditions to test the hypothesis of domain-specific impairments in AD. Consequently, a recognition procedure was used in all conditions, and learning occasions were equated across musical and verbal materials. Another aspect of the method was to match familiarity across domains by comparing LTM for pseudowords to LTM for unfamiliar musical excerpts. Neither pseudowords nor unfamiliar melodies have representations in a verbal/musical lexicon. Furthermore, pseudowords do not carry meaning,