The Effects of Normal Aging on Source Memory for Odors

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Source and item memory for olfactory stimuli were assessed in healthy older (65+) and young adults. During the study phase, a male and a female source presented 16 odors to each participant one at a time. Each source presented 8 odors to the participant. As a way to assess source memory, the participant was asked to indicate whether an odor from the study phase was presented by the male or female. As a way to assess item memory, a study phase odor and a novel odor were presented and the participant was asked to indicate which was presented previously. Source memory for odors was impaired in older adults compared with young adults. However, there were no significant differences in odor item memory between young and older adults. Thus, source memory for olfactory stimuli may be a task that is particularly sensitive to age-related changes in the brain.

Psychophysical data have shown that healthy older adults show deficits in odor detection (Nordin & Murphy, 1998), odor identification (Murphy et al., 2002; Wysocki & Gilbert, 1989), and odor recognition memory (Murphy, Cain, Gilmore, & Skinner, 1991). Studies report that older adults are often unaware of their olfactory loss (Murphy et al., 2002) and may be more likely to develop Alzheimer’s disease by a 2-year follow-up than older adults who are aware of their olfactory impairment (Devanand et al., 2002).

Age-related neuropathological changes have been documented in cortical regions of the brain that process olfactory information such as the mesial temporal lobe (Price, Davis, Morris, & White, 1991) and the frontal cortex (Raz, 2000). Data collected by use of functional magnetic resonance imaging (fMRI) demonstrated that, when participants were presented with olfactory stimuli, older adults showed activation in olfactory areas of the brain that was similar to that of young adults; however, the degree of activation in older adults was significantly lower in the mesial temporal lobe and orbital frontal cortex (Cerf-Ducastel & Murphy, 2003).

Memory loss is commonly associated with aging; however, not all domains of memory may be equally affected. Memory for the context from which a specific item was acquired is often referred to as source memory, whereas memory for facts is often referred to as item memory. Research has demonstrated that source memory is more affected by aging than item memory (Schacter, Osowiecki, Kasznia, Kihlstrom, & Valdiserri, 1994; Trott, Friedman, Ritter, Fabiani, & Snodgrass, 1999). Larsson and Backman (1998) examined whether older adults could recall the modality (source) from which a stimulus was presented. The majority of errors in source memory in that study involved confusions between auditory and olfactory stimuli. Aside from this study reporting confusions in source memory between auditory and olfactory stimuli, to our knowledge no research has been conducted to examine source memory for olfactory stimuli in older individuals. Because aging has been shown to result in impairments in both odor memory and source memory, a task that combines both olfactory and source memory may be particularly sensitive to the effects of aging.

In the present study we compared source and item memory for olfactory stimuli in healthy older and young adults. We hypothesized that source memory for olfactory stimuli would be poorer in older adults than it was in younger adults. However, we predicted item memory for olfactory stimuli to be similar between young and older adults.

Methods

Participants

We assessed source and item memory for olfactory stimuli in young (n = 14) and older (n = 14) adults. We recruited the young participants from a pool of college students at San Diego State University (SDSU). Older participants were active community-dwelling individuals taking part in a longitudinal study at the Center for Lifespan Human Senses at SDSU. We screened all older participants for dementia by using the Dementia Rating Scale (Mattis, 1976). Table 1 provides a summary (mean ± standard error) of the demographic information and performance on the Dementia Rating Scale and Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975). Analyses of variance (ANOVAs) with group (young adults, older adults) as a between-group factor did not detect any significant differences between the young and older adults on the MMSE, F(1, 26) = 0.53, p = .47, or in years of education, F(1, 26) = 0.84, p = .37.

Alcohol Sniff Test

We screened each participant for anosmia by using the Alcohol Sniff Test (Davidson & Murphy, 1997). To familiarize the participant with the smell of the alcohol, the experimenter presented each participant with a standard 70% isopropyl alcohol pad with only 0.5 cm of the pad exposed from the package. The participant was seated in an upright position and held a standard metric tape measure, positioned so that it extended downward from the nostril. The experimenter asked the participant to close her or his eyes and mouth and breathe normally through the nose. The experimenter presented the alcohol pad 30 cm below the participant’s nose; with each expiration, they moved the pad 1 cm closer to the nose until the participant detected the odor. The experimenter measured the distance (in centimeters) from the nostril to the alcohol pad, and we used this as the dependent measure. The procedure was repeated five times, and we
determined the threshold on the basis of the mean distance required to detect the odor. The performance (mean ± standard error) of each group is shown in Table 1. An ANOVA did not detect any significant differences were between young and older adults, $F(1, 26) = 0.28, p = .60$.

Source and Item Memory for Olfactory Stimuli

We assessed source and item memory for olfactory stimuli by using a paradigm developed particularly for this experiment. We used 24 odors as test stimuli. Experimenters presented 16 odors during the study phase of testing, and they used 8 as distractors to measure item memory during the test phase. We randomly selected the 16 target stimuli and 8 distractor stimuli for each participant.

During the study phase, experimenters presented each participant with 16 odors one at a time in a randomly predetermined sequence that differed for each participant. Odors were presented in small opaque glass jars and consisted of common household odors such as chocolate, coffee, cinnamon, and the like. Three experimenters were involved in testing. Two experimenters (sources), one male and one female, each wore a white lab coat and were involved only in presenting the stimuli during the study phase of the experiment. The other experimenter conducted the test phase of the experiment. Each participant was instructed that she or he would receive a series of odors and was to smell each odor for 5 s. There was no mention of any subsequent recall or recognition of the odors.

During the study phase, the male and female source experimenters presented each of the odors one at a time to the participant in an alternating sequence so that the first odor was presented by the male, the second by the female, and so forth until each source experimenter had presented 8 odors for a total of 16. The male source presented the first stimulus for half the participants and the female presented first for the other half. In addition, the stimuli presented by the male and female source were randomly selected for each participant. The two source experimenters sat side by side, facing the participant. A partition was positioned in front of each source experimenter to block the stimuli from the view of the participant. A small space (15 cm) between the two partitions permitted the experimenters to present each stimulus directly in front of the participant to minimize positional cues. When each stimulus was presented, the source would state, “here is your next odor.” Once all of the 16 odors were presented, both source experimenters exited the room and the test phase began.

The third experimenter conducted the test phase. Test phase trials consisted of two different types of two-alternative forced-choice tasks to assess item and source memory. We intermingled the item recognition trials and the source memory trials, and we randomly determined the presentation sequence for each participant. To assess item memory, we presented each participant with eight recognition trials. The experimenter randomly selected 8 odors used to assess item memory from the 16 odors presented during the study phase. On each recognition trial, the experimenter simultaneously presented the participant with 1 odor previously presented during the study phase and 1 distractor odor not previously presented. The experimenter presented the 2 odors to the participant for 10 s, allowing approximately 5 s to smell each odor. The experimenter presented the 2 odors side by side, and the participant chose which odor to sample first. We randomly determined the position of the old stimulus (left vs right) for each trial. The experimenter asked the participant to choose which of the 2 odors was presented during the study phase. We also conducted eight trials to assess source memory. We used the 8 remaining odors from the sample phase not used for item recognition trials for source memory trials so that source and item memory trials were independent. On each source memory trial, the experimenter presented the participant with one of the 8 odors and asked her or him to indicate whether the odor was presented by the male experimenter or the female experimenter. The experimenter recorded the response of the participant, and we used this as the dependent measure. We implemented a 30-s interstimulus interval between the presentation of all stimuli to avoid adaptation. We converted the raw data for the source and item memory trials into percent correct scores.

RESULTS

Source and Item Memory

A $2 \times 2$ ANOVA with group (young, older) as a between-group factor and trial type (source, item) as a within-group factor revealed a significant main effect of group, $F(1, 26) = 10.32, p < .01$; a significant main effect of trial type, $F(1, 26) = 45.54, p < .001$; and a significant Group × Trial type interaction, $F(1, 26) = 24.88, p < .001$. A Newman–Keuls post hoc comparison test of the Group × Trial type interaction revealed that source memory for odors was significantly worse ($p < .05$) in older adults than in young adults (Figure 1). However, the analysis did not detect any significant differences between young and older adults on item memory for odors (Figure 1).

DISCUSSION

The results of the present study indicate that source memory for odors was impaired in older adults compared with young adults.

Table 1. Mean (± Standard Error) Demographics, Alcohol Sniff Test Thresholds, and Scores on the MMSE and Dementia Rating Scale for Young and Older Adults

<table>
<thead>
<tr>
<th></th>
<th>Young Adults</th>
<th>Older Adults</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (male/female)</td>
<td>6/8</td>
<td>6/8</td>
</tr>
<tr>
<td>Age (years)</td>
<td>18.79 ± .43</td>
<td>76.00 ± 2.43</td>
</tr>
<tr>
<td>Education (years)</td>
<td>13.36 ± .23</td>
<td>14.00 ± .66</td>
</tr>
<tr>
<td>MMSE</td>
<td>29.36 ± .25</td>
<td>29.07 ± .31</td>
</tr>
<tr>
<td>DRS</td>
<td>NA</td>
<td>141.07 ± .75</td>
</tr>
<tr>
<td>AST (cm)</td>
<td>22.94 ± 1.58</td>
<td>23.88 ± .81</td>
</tr>
</tbody>
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Notes: MMSE = Mini-Mental State Examination; DRS = Dementia Rating Scale; AST = Alcohol Sniff Test.

Figure 1. Mean percent correct performance (± standard error) on source memory and item memory trials for olfactory stimuli in young and older adults.
However, we detected no significant differences in item memory for olfactory stimuli. The present results are consistent with prior studies reporting that source memory is more affected by aging than is item memory for verbal and visual stimuli (Schacter et al., 1994; Trott et al., 1999). Neuroimaging studies have shown decreased activity in the frontal lobes of older adults performing an olfactory task (Cerf-Ducastel & Murphy, 2003). Age-related degeneration in the frontal lobes also has been suggested to contribute to impairments in source memory (Craik, Morris, & Loewen, 1990; Glisky, Rubin, & Davidson, 2001; Johnson, Hashtroudi, & Lindsay, 1993). Because the present task combines olfactory memory and source memory, the task may be particularly sensitive to age-related frontal lobe dysfunction. However, some researchers have suggested that age-related impairments in source memory may be associated with temporal lobe dysfunction (Henkel, Johnson, & De Leonardis, 1998).

Source memory impairments associated with aging may result from poor encoding of contextual information (Johnson et al., 1993). Age-related frontal lobe dysfunction is suggested to result in a failure to initiate mnemonic processes required to integrate contextual information with item memory during encoding (Glisky et al., 2001). In older adults, the encoding of the stimulus itself may require so much effort that the individual is unable to encode contextual information such as the source from which the stimulus was acquired (Castel & Craik, 2003; Troidy, Winocur, Craik, & Moscovitch, 1999). Therefore, the more difficult it is to encode the stimulus, the more difficult it may be to encode and subsequently retrieve the source. Studies have shown that memory for olfactory stimuli may be inferior to memory for visual or verbal stimuli (Murphy et al., 1991; Nordin & Murphy, 1998) and may require more effort during encoding. Therefore, difficulty encoding the olfactory stimuli in the present task may contribute to the deficit in source memory observed in older adults. Although olfactory encoding may require more effort, the item recognition data show that older adults can encode the olfactory stimuli as well young adults. Item memory has been associated with temporal lobe function (Shimamura & Squire, 1987). These data indicate that the deficits observed on the source memory task are not the result of impaired memory for the individual odors.

The present findings add to a growing body of literature suggesting that olfactory memory may be significantly impaired as a result of age-related degeneration in the brain. The olfactory source memory task may be very sensitive to the frontal lobe dysfunction associated with aging because the task combines both olfactory and source memory.

Acknowledgments

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References


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