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Auditory Confrontation Naming in Alzheimer's Disease

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Abstract

Naming is a fundamental aspect of language and is virtually always assessed with visual confrontation tests. Tests of the ability to name objects by their characteristic sounds would be particularly useful in the assessment of visually impaired patients, and may be particularly sensitive in Alzheimer's disease (AD). We developed an Auditory Naming Task, requiring the identification of the source of environmental sounds (i.e., animal calls, musical instruments, vehicles) and multiple-choice recognition of those not identified. In two separate studies, mild-to-moderate AD patients performed more poorly than cognitively normal elderly on the Auditory Naming Task. This task was also more difficult than two versions of a comparable Visual Naming Task, and correlated more highly with Mini-Mental State Exam score. Internal consistency reliability was acceptable, although ROC analysis revealed auditory naming to be slightly less successful than visual confrontation naming in discriminating AD patients from normal subjects. Nonetheless, our Auditory Naming Test may prove useful in research and clinical practice, especially with visually-impaired patients.

Naming, the process of providing a verbal label to an object or concept (Horne & Lowe, 1996; Price et al., 1996; Humphreys et al., 1999), is a fundamental aspect of language. It is an early-developing linguistic ability whose impairment in neurologic disease can be the source of significant disability (Raymer & Rothi, 2002).

Visual confrontation naming (i.e., naming seen objects or pictures of objects or actions) is typically impaired very early and severely in Alzheimer's disease (AD) (Barker & Lawson, 1968; Tippett & Farah, 1994; Lukatela et al., 1998) and appears to decline in a linear fashion (Rebok et al., 1990). In fact, difficulties with naming have even been reported among non-demented people at high risk for AD (Miller et al., 2005).

Naming deficits also appear to have some specificity for AD, as they are much less severe in equivalently demented patients with subcortical vascular dementia (Barr et al., 1992; Almkvist, 1994; Golden et al., 2005; Lukatela et al., 1998), Parkinson's disease (Bayles & Tomoeda, 1983; Pillon et al., 1991; Stern et al. 1993) or Huntington's disease (Bayles & Tomoeda, 1983; Brandt et al., 1988; Hodges et al., 1991). Patients with the temporal lobe variant of frontotemporal lobar degeneration or dementia with Lewy bodies (DLB) tend to have naming impairments as severe as those with AD (Grossman et al., 2004; Lambon

Ralph, Graham, Ellis & Hodges, 1998; Lambon Ralph, Powell, Howard et al., 2001; Noe et al., 2004; but cf. Kraybill et al., 2005).

Virtually every neuropsychological test battery for the detection of dementia, its differential diagnosis, or the monitoring of its course includes a test of visual confrontation naming (Beekly et al., 2004; Locascio et al., 1995; Welsh et al., 1992, 1994). The Boston Naming Test, in either its original form (Kaplan, Goodglass & Weintraub, 1983) or any one of a number of short-forms (Fastenau et al., 1998; Lansing et al., 1999; Saxton et al., 2000), is the most popular test for these purposes (Butler et al., 2000; Rabin et al., 2005). However, it could be argued that a primary disorder of naming should be independent of modality of stimulus presentation. Given the known degeneration of the temporal cortex and the central auditory pathways in AD (Sinha et al., 1993), it might even be reasonable to suspect that accessing object names by their sounds would be impaired earlier or more severely in AD than accessing object names by their visual appearances. In addition, several studies suggest that tests of auditory naming may be more sensitive than tests of visual confrontation naming to patient complaints of word-finding difficulties and anomia in everyday speech (Bell et al., 2003; Hamburger & Tamny, 1999; Hamburger & Seidel, 2003).

Most prior studies of auditory naming required participants to identify objects from spoken verbal descriptions, often referred to as “responsive naming” (Bell et al., 2003; Bookheimer et al., 1998; Malow et al., 1996; Rebok et al. 1990) or, more recently, “descriptive naming” (Miller et al., 2010). Such tasks clearly make greater demands on language comprehension than those that require accessing object or concept names by the characteristic sounds they produce. Accessing the name of an object from its auditory “appearance” is likely to be more similar in processing demands to accessing that name from the object’s visual appearance than is accessing it from a spoken definition. For these reasons, the present report focuses on identifying objects perceived auditorily; hence, auditory confrontation naming.

A further impetus for investigating auditory confrontation naming in dementia is the need for clinical tests of naming that do not depend on vision. As every clinician knows, macular degeneration, cataracts, and other eye disorders are extremely common among the elderly and are responsible for significant visual disability (Klaver et al., 1998; West et al., 1997; Wormald et al., 1992). The estimated prevalence of blindness and visual impairment reaches 30% in those over age 85 (Klaver et al., 1998). The development of a reliable, sensitive and specific auditory confrontation naming test would facilitate the cognitive assessment of such patients. Here, we report on the initial development of such a test. We also present data on its internal consistency reliability and its ability to discriminate between patients with AD and normal older adults.

STUDY 1

Methods

Subjects—Twenty-eight patients with probable Alzheimer’s disease were recruited from the Alzheimer’s Disease Research Center (ADRC), other research studies, and clinics at the Johns Hopkins University School of Medicine. Patients were diagnosed based on all available clinical information (i.e., excluding the experimental tasks), applying NINCDS-ADRDA criteria (McKhann et al., 1994). All cases were reviewed at diagnostic conferences, where the consensus of faculty physicians and neuropsychologists specializing in dementia was obtained. Under these conditions, diagnostic accuracy exceeds 90% (Burns et al., 1990; Morris et al., 1988; Rasmusson et al., 1996). All patients had scores of at least 12 on the Mini-Mental State Exam (MMSE).

Seventy-four neurologically normal older adults served as control subjects. They too were participants in the ADRC or other clinical research studies, or were recruited from a retirement community. All control subjects were examined neurologically, psychiatrically, and neuropsychologically, and all were adjudicated to be cognitively normal.

All the patients and control subjects were highly competent in the English language. Since these participants were drawn from several different sources, they were not characterized with a consistent neuropsychological test battery. However, they were all administered the MMSE, and about half of them were administered a 30-item short-form of the Boston Naming Test (BNT-30).

All participants (and, where appropriate, their surrogate decision-makers) gave informed consent to this testing in the context of research protocols that were fully reviewed and approved by the Johns Hopkins Institutional Review Board.

Procedures—Participants were tested individually in a quiet, well-lit room. They were encouraged to use eyeglasses and/or hearing aids, as needed. No subject reported sensory impairment that would preclude testing, nor was any clinically significant visual or hearing loss described in available medical records.

Auditory Naming Task: Line drawings of 20 objects that produce characteristic sounds were selected from the Snodgrass and Vanderwart (1980) picture set. The items selected belonged to one of three categories: musical instruments, transportation vehicles, and animals. (See the Appendix for the specific items chosen.) For each item, several sound files in the public domain were downloaded from the Internet. Ninety-three such sound clips were presented to 10 volunteers (laboratory and clinic staff) who were asked to identify the objects that produce the sounds. The sound clips with highest name concordance rates were selected. The selected sound-clips were edited for relatively consistent length (6 sec.) and volume using standard audio editing software (Anderberg, 1998) and recorded on high-quality audio tape.

On each trial, a sound clip was played and the subject was asked to identify the thing or object producing the sound. Accuracy was recorded, but latency to respond was not. If the subject responded incorrectly, a five-alternative, multiple-choice recognition trial was administered. In addition to the correct answer, there were four recognition foils: one name from each of the three semantic categories [animal calls, transportation vehicle noises, and music (brief novel melodies or arpeggios) played on a single instrument], as well as an unrelated object capable of making a sound. For example, if a participant was unable to name correctly the sound of a helicopter, s/he was provided with five words from which to choose: whistle (unrelated), drum (music), helicopter (target), train (vehicle), and cat (animal). These options were printed on a card, shown to the participant, and read out loud by the examiner. The participant was then asked to select one. A single practice trial (a ringing telephone) was followed by 20 test trials. Number of stimuli identified spontaneously, and number whose names were correctly selected on multiple-choice recognition, were tabulated.

Visual Naming Task: The same 20 line drawings of target objects from the Auditory Naming Task were used to create a visual naming test. The drawings were enlarged and photocopied onto letter-size pages. These pictures were shown one at a time to participants, who were asked to name them. There was no time limit for responding, and accuracy was recorded. Any incorrect response was followed by a five-alternative recognition trial. In addition to the correct name, the choices included one semantically-related object name, one phonetically-similar name (usually just number of syllables or initial phoneme), the name of

one visually-similar object, and one unrelated object name. Again, the options were printed, shown to the participant, and read out loud by the examiner. The participant was asked to select one. The number of items correctly named (identified) spontaneously and the number whose names were correctly recognized were recorded.

The order of administering the two experimental naming tasks was haphazard. Sixty-one percent (61%) of the AD patients and 49% of the control participants were administered the Auditory Naming Task first. Since order was not significantly related to number of items correctly named on either task, the data were pooled across administration orders.

Results

The AD and normal control groups were comparable in sex distribution and average age, but they differed in educational background (see Table 1). As expected, there was a large difference between the groups in score on the MMSE and BNT-30. A few participants from each group were excluded from the following analyses because of missing data.

Number of items spontaneously identified (i.e., named correctly) was the dependent variable of primary interest on the naming tasks. Number recognized on multiple-choice was of secondary interest. Since the distributions of both these scores were highly skewed, and not amenable to logarithmic transformation, nonparametric tests were employed. Wilcoxon tests and Mann-Whitney U tests were used to assess within-group and between-group differences, respectively.

The Auditory Naming Task proved to be more difficult than the Visual Naming Task. Both AD patients and normal elderly obtained significantly lower naming scores on auditory than visual naming ($z = 7.03$, $p < .001$ and $z = 4.42$, $p < .001$, respectively).

The AD patients displayed significant naming impairment on both tasks. They obtained lower spontaneous correct scores than the normal control subjects on the Auditory Naming Task ($z = 4.73$, $p < .001$) as well as the Visual Naming Task ($z = 5.73$, $p < .001$).

The number of additional items correctly named with the multiple-choice recognition format was constrained by the very small number of items not correctly named spontaneously, particularly for the visual task (and especially for the normal control subjects). The AD patients earned more additional points on the recognition procedure than did the normal elderly ($z = 3.51$, $p < .001$ for the auditory task; $z = 5.50$, $p < .001$ for the visual task).

The fact that the Visual Naming Task was significantly easier than the Auditory Naming Task makes it difficult to assess any differential deficit in auditory naming in the AD group. Therefore, a second study was performed in which a new, hopefully more difficult visual naming test was developed and administered to new samples of AD patients and normal control subjects along with the Auditory Naming Task.

STUDY 2

Methods

Subjects—Twenty patients with probable Alzheimer's disease and 56 neurologically normal, non-demented elderly controls participated in this study. They were selected using the same criteria and drawn from the same sources as in Study 1.

Procedures—Participants were administered the MMSE, the same Auditory Naming Task as in Study 1, and a revised visual naming task. For this task, we abandoned the idea of using pictures of the same objects used in the Auditory Naming Task. Instead, we selected

line drawings of 20 different objects from the Snodgrass and Vanderwart (1980) corpus that closely matched items on the Auditory Naming Task in familiarity rating. (See the Appendix for the specific items chosen.) Sixty percent (60%) of the AD patients and 62% of the control subjects were administered the Auditory Naming Task first, followed by the Visual Naming Test; the remaining subjects performed the tasks in the reverse order.

Results

The AD participants and control subjects differed in mean age, and, as expected, in MMSE and BNT-30 scores (see Table 2). Of note, the AD patients in this study were less cognitively impaired, as measured by mean MMSE scores, than those in Study 1. Since order of naming task administration was not significantly related to number of items correctly named on either task (see Table 3), the data were pooled across administration orders. One normal control subject was excluded from the following analyses because of missing data.

We were unsuccessful in our effort to create a Visual Naming Task as difficult as our Auditory Naming Task. Both AD patients ($z = 3.06$, $p < .001$) and normal control subjects ($z = 4.19$, $p < .001$) still obtained lower naming scores on the auditory task than on the revised visual task.

The internal consistency reliability of each test was estimated in the entire Study 2 sample (AD patients and control subjects combined to maximize score variability). As the scores reflect dichotomous decisions (i.e., correct or incorrect), reliability was calculated with the Kuder-Richardson formula 20. The Visual Naming Test had modest internal reliability ($\alpha = .61$), whereas the Auditory Naming Test had somewhat higher internal consistency ($\alpha = .78$).

Correlates of performance on the two naming tasks are shown in Table 4. Among normal elderly, performance on the Auditory, but not the Visual, Naming Task is inversely associated with age. In both groups, the BNT-30 is more highly correlated with the Visual Naming Test than the Auditory Naming Test, as expected. Among the AD patients, severity of dementia (as indexed by MMSE score) was a stronger correlate of auditory than visual naming.

As in Study 1, the AD subjects obtained lower scores than the control subjects on both the Auditory Naming Task ($z = 2.79$, $p < .001$) and the Visual Naming Task ($z = 4.08$, $p < .001$). Also as in Study 1, the number of additional items recognized on multiple-choice was higher for the AD group on both the auditory task ($z = 2.75$, $p = .001$) and the visual task ($z = 3.34$, $p = .001$), due largely to a ceiling effect in the normal subjects.

Receiver operating characteristic (ROC) curves were drawn to examine the sensitivity and specificity of the naming tasks (see Figure 1). The area under the curve (AUC) for the Visual Naming Task (.804) was slightly higher than that for the Auditory Naming Task (AUC = .708). For the Auditory Naming Task, applying a cutoff score of 15/16 resulted in correctly classifying 65% of our mild AD patients and 76% of our normal control subjects. For the Visual Naming Task, applying the same cutoff score (optimal for balancing sensitivity and specificity) resulted in correctly classifying 65% of the mild AD patients and over 96% of the normal control subjects.

Discussion

We have developed a brief, sound-based, object naming task that is sensitive to the mild dementia of early Alzheimer's disease. The test does not have a ceiling effect in normal elderly, has respectable internal consistency, and correlates strongly with severity of dementia in AD. This task allows the assessment of a fundamental aspect of language in

persons with visual impairments that would preclude or confound testing with traditional confrontation naming tasks (e.g., Boston Naming Test).

In spite of our efforts to create visual and auditory naming tasks of equal difficulty, both our AD patients and our normal control subjects obtained lower scores on the Auditory Naming Test than on either version of our visual naming task. The fact that auditory naming was more difficult for both groups may, of course, reflect the specific stimuli chosen. Alternatively, it may be that identifying and naming objects by their characteristic sounds is inherently more difficult than naming line drawings of objects. The neurocognitive reasons for this are not entirely obvious, but one hypothesis is that auditory naming places greater demands on speed of processing and working memory than does visual naming. When naming the characteristic sounds of objects, participants must be able to parse brief auditory signals and make fine temporal discriminations. Most tests of visual confrontation naming, including ours, allow significantly longer exposure to static stimuli. Modifications to our procedure might be considered in future studies to make stimulus presentation more comparable across sensory modalities. These include allowing repeated presentation of sound clips until named, having briefer (e.g., tachistoscopic) presentation of visual naming stimuli, or creating temporally dynamic visual stimuli (very brief movies or cartoons of objects in action).

Another possibility, not mutually exclusive with the first, is that there is a fundamental difference between the information conveyed by auditory and visual naming test stimuli. Prototypical object sounds are often not inherent in the objects themselves, but are associated with, or are generated by, the *function* of such items. For example, a drum by itself has a visual appearance but makes a sound only when operated on by a drummer. A train or airplane is silent when it is at rest; it is only when it is in operation that a sound is produced. Thus, the visual features an object prototype may be more fundamental or obligatory components of its semantic representation than the sounds that that object can make under specific conditions.

Limitations of our task administration and scoring methods may have obscured finer qualitative differences between the auditory and visual tasks. First, we did not record response latencies, as we wished to simplify test administration and model how the test might be used in clinical practice. However, Jeon & Lee (2009) found that response latency in sound naming was particularly sensitive to severity of dementia in AD. In addition, we did not systematically record paronomias or categorize error types. The nature of naming errors may be quite different for visual and auditory naming tasks, and might contribute to the diagnostic value of the tests. For example, Williams et al. (2007) demonstrated that analysis of error types on the Boston Naming Test distinguished between patients with DLB and those with AD, independent of total score. Specifically, DLB patients made more visuo-perceptual errors, whereas AD patients made more semantic errors.

Another modification that might be considered in future studies is the imposition of a cued recall trial prior to the multiple-choice recognition trial. However, the construction of phonemic and semantic cues must be done with care, as the extent to which such cues constrain the set of possible names in existing naming tests is extremely variable. It might also be argued that a 20-item test is too brief to be reliable and valid. Having a larger number of test items, especially those of greater difficulty, may improve the psychometrics of the test, but the trade-off is longer administration time and, possibly, lower acceptability to patients. We note as well that an even briefer, 15-item version of the Boston Naming Test is widely used as part of the CERAD neuropsychological battery and contributes significantly to the detection of mild AD (Welsh et al., 1992).

Although our Auditory Naming Task was not as successful as our revised Visual Naming Test in discriminating mild AD patients from cognitively normal elderly, it had higher internal consistency reliability and correlated more highly with dementia severity. It may still be useful in situations where visual confrontation naming would be problematic, or where access to the lexicon via the auditory modality is of particular interest. Before our Auditory Naming Task could be recommended for clinical use, its psychometric properties (including construct validity and test-retest reliability) would need to be tested fully and found acceptable. Such studies are currently underway.

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Appendix

Names of items on the Auditory Naming Test used in Studies 1 and 2, and the Visual Naming Task in Study 2.

	Auditory Naming	Visual Naming
1	Duck	Wheel
2	Violin	Flag
3	Train/Locomotive	Swan
4	Horse	Mouse
5	Harp	Axe
6	Chicken	Donkey
7	Pig	Peacock
8	Airplane	Motorcycle
9	Rooster	Ant
10	Drums	Piano
11	Cat	Suitcase
12	Frog	Nut
13	Helicopter	Foot
14	Bird	Television
15	Accordion	Spider
16	Elephant	Ball
17	Dog	Penguin
18	Guitar	Rhinoceros
19	Owl	Swing
20	Cow	Lobster

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Figure 1.
Receiver operating characteristic curve for spontaneous correct scores of the Auditory and Visual Naming Tasks.

Table 1

Characteristics of samples in Study 1. Means (+ SDs), unless otherwise indicated.

	Normal Elderly	Alzheimer's Disease	<i>P</i>
N	74	28	
Sex (M/F), #	18/56	7/21	.944
Age, yrs.	81.27 (8.47)	82.87 (7.49)	.390
Education, yrs.	15.76 (2.59)	13.50 (3.46)	.008
Mini-Mental State Exam, score	28.43 (1.63)	17.52 (3.92)	<.001
Boston Naming Test (30-item), score	28.00 (2.79) (N=58)	18.00 (7.85) (N=7)	.015
Auditory Naming Test , # correctly named	14.58 (4.50)	9.73 (3.35)	<.001
Auditory Naming Test, # correctly recognized	3.97 (3.00)	6.19 (2.64)	<.001
Visual Naming Test , # correctly named	19.27 (1.08)	16.00 (2.81)	<.001
Visual Naming Test, # correctly recognized	0.72 (1.04)	3.42 (2.25)	<.001

Table 2

Characteristics of samples in Study 2. Means (+ SDs) and ranges, unless otherwise indicated.

	Normal Elderly	Alzheimer's Disease	<i>p</i>
N	56	20	
Sex (M/F), #	25/31	12/8	<.238
Age, yrs.	78.16 (7.49)	72.45 (8.36)	<.006
Education, yrs.	15.08 (2.34)	15.05 (3.36)	.965
Mini-Mental State Exam, score	28.48 (1.50)	22.20 (3.94)	<.001
Boston Naming Test (30-item), score	28.58 (1.39) (N=19)	23.21 (4.76) (N=19)	<.001
Auditory Naming Test, # correctly named	16.40 (3.21) Range 7-20	14.10 (3.61) Range 6-20	<.001
Auditory Naming Test, # correctly recognized	2.89 (2.35)	4.25 (2.17)	.001
Visual Naming Test, # correctly named	18.49 (1.50) Range 15-20	16.20 (2.40) Range 9-20	<.001
Visual Naming Test, # correctly recognized	1.40 (1.41)	3.05 (2.24)	.001

Table 3

Descriptive statistics of Auditory and Visual Naming Tests in Study 2 as a function of test order administration. Means (+ SDs).

	Normal Elderly	Alzheimer's Disease
Auditory Task when first	16.67 (2.67)	13.75 (3.42)
Auditory Task when second	16.38 (3.57)	14.63 (4.07)
Visual Task when first	18.00 (1.79)	15.88 (3.14)
Visual Task when second	18.82 (1.24)	16.42 (1.88)

Table 4

Correlates of performance on the Visual and Auditory Naming Tests. Spearman correlations (and *p*-values).

	Normal Elderly		Alzheimer's Disease	
	Visual	Auditory	Visual	Auditory
Age, yrs.	-.078 (.572)	-.432 (<.001)	-.574 (.008)	-.406 (.075)
Education, yrs.	-.049 (.724)	-.050 (.715)	.147 (.536)	.086 (.718)
Mini-Mental State Exam, score	.312 (.020)	-.036 (.793)	.514 (.020)	.649 (.002)
Boston Naming Test (30-item), score	.411 (.080) (N=19)	-.120 (.625) (N=19)	.776 (<.001) (N=19)	.526 (.021) (N=19)