Using lexical familiarity judgments to assess verbally mediated intelligence in aphasia

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Abstract:

In this study, a task using forced-choice lexical familiarity judgments of irregular versus archaic words (a newly developed measure called the Lexical Orthographic Familiarity Test; LOFT) was compared to a standardized oral word-reading measure (the Wechsler Test of Adult Reading; WTAR) in a group of 35 aphasic adults and a comparison group of 125 community dwelling, nonbrain damaged adults. When compared to the comparison group, aphasics had significantly lower scores on the WTAR but not the LOFT. Although both the WTAR and LOFT were significantly correlated with education in the nonbrain-damaged group, only the LOFT was correlated with education and also with the Barona full scale IQ index in the aphasic group. Lastly, WTAR performance showed a significantly greater relationship to the severity of language disorder in the aphasic group than did the LOFT. These results have both theoretical and clinical implications for the assessment of language-disordered adults, as they indicate that patients with aphasia may retain aspects of verbally mediated intelligence, and that the LOFT may provide a better estimate of premorbid functioning in aphasia than other currently available measures.

Keywords: premorbid intelligence | lexical processing | lexical-semantics | aphasia | test reliability | test validity

Article:

The estimation of premorbid intelligence has long been recognized to be a vital component of neuropsychological and speech-language evaluations. In addition to providing a framework from which to interpret current performance on cognitive tests, knowledge of an individual's baseline level of functioning can have important implications for guiding treatment plans or implementing rehabilitation strategies. For example, when considered together with performance in other neuropsychological domains, establishing estimated premorbid intelligence can help to more reliably diagnose particular deficits (Tremont, Hoffman, Scott, & Adams, 1998; Lezak, Howieson, & Loring, 2004). Additionally, it has even been known to influence factors such as prognosis (Anson & Ponsford, 2006; Kesler, Adams, Blasey, & Bigler, 2003; Pavlik, Doody, Massman, & Chan, 2006), response to particular interventions (Fiszdon, Choi, Bryson, & Bell,

2006), and even long-term outcome in cognitive disorders (Pavlik, Doody, Massman, & Chan, 2006).

Unfortunately, the determination of verbally mediated premorbid intellectual abilities in patients with language impairments presents a particularly difficult challenge because most measures of IQ will be affected by the patients' instrumental linguistic deficits. For example, one of the most common methods for estimating premorbid intelligence is based on oral word reading. The best known of these measures are the widely used National Adult Reading Test (NART) and its variant the American National Adult Reading Test (ANART). These tests require the accurate pronunciation of 50 words that vary with regard to irregularity and difficulty (Nelson & Willison, 1991). The more recently developed Wechsler Test of Adult Reading (WTAR) exclusively contains words that cannot be pronounced based on grapheme to phoneme conversion, and thus requires a knowledge base, or at the very least, familiarity of such words. Interpretation of performance is based on the idea that prior, lifelong exposure to a word, even without knowledge of the meaning per se, is a reflection of premorbid verbal intellectual functioning (Wechsler, 2001). Reading words aloud, particularly orthographically irregular words that comprise such tests as the ANART and WTAR, can be difficult and sometimes impossible for patients with both fluent and nonfluent aphasic symptoms (Goodglass, Kaplan, & Barresi, 2001). Furthermore, a number of theories of language disorders suggest that at least some aphasic symptoms are based on an erosion or deterioration of the representational basis of word meaning, a deficit that would undermine access to the very information needed to assess verbally mediated intellectual abilities (Chertkow, Bub, Deaudon, & Whitehead, 1997; Cohen, Kelter, & Woll, 1980; Jeffries & Lambon Ralph, 2006; Semenza, Denes, Lucchese, & Bisiacchi, 1980; Warrington & Cipolotti, 1996).

However, several studies challenge the notion of a one-to-one correspondence between language ability and verbal intelligence. In particular, past research suggests that a dissociation may exist between actual *access* to aspects of linguistic information, and the *presence* of the underlying representations themselves (Milberg & Blumstein, 1981). Accordingly, impairments on tasks of verbal intellectual abilities, such as the NART or WTAR, may be because of a deficit in the ability to activate or retrieve linguistic information, as opposed to a breakdown in verbal intelligence, per se. If this were true, it would imply that there are aspects of verbal intelligence that are not dependent on the processes that underlie aphasic symptoms. Indeed, there is substantial evidence to suggest that despite profound speech and language impairments, patients with aphasia can access certain aspects of lexical information, albeit under implicit or indirect conditions (Friedman, 1981; Milberg & Blumstein, 1981; Mimura, Goodglass, & Milberg, 1996), suggesting that at least some of the linguistic difficulties in patients with aphasia may be traced to impaired access to lexical information, as opposed to disruption of lexical-semantic networks per se.

The foregoing review leads to the question of whether the processes that support lexical priming in aphasia are related to verbal intellectual functioning, and whether such processes can be exploited to develop new methodologies to measure premorbid intelligence in aphasic individuals. One test that could potentially be used for this purpose is the Spot-the-Word Test

developed by Baddeley (1993) and colleagues. The Spot-the-Word is designed for use in conjunction with the NART and is based on lexical decision as opposed to actual word production (Baddeley, Emslie, & Nimmo-Smith, 1993). In the Spot-the-Word test, patients are presented with pairs of items containing one real word and one nonword, and are asked to identify the "real" word (Baddeley, Emslie, & Nimmo-Smith, 1993). Although combined use of the Spot-the-Word and the NART has provided preliminary evidence that a "word familiarity" method of premorbid IQ estimation may be useful in cognitively impaired populations (Beardsall, 1997), the NART is problematic for use in patients with dyslexia or in patients with phoneme production deficits who may have trouble reading aloud. Its use of orthographically irregular words also makes it difficult to translate in languages whose pronunciation rules are more heavily tied to orthography, and the fact that it was developed in Britain makes it less than ideal for use with American speakers (Baddeley, Emslie, & Nimmo-Smith, 1993). In addition, the Spot-the-Word was normed on only 50 healthy participants, thus having a fairly limited normative base and making it more challenging for general use in patients with aphasia. To date there are no published data to evaluate the efficacy of the Spot-the-Word with aphasics.

The current study investigated the utility of the Lexical-Orthographic Familiarity Test (LOFT) in assessing verbally mediated premorbid function in aphasics. The LOFT is a forced-choice recognition task based on lexical familiarity judgments, a variation of the lexical-decision task using instructions that has been found in our clinical experience to be easier for aphasic patients to perform than the standard lexical-decision task. Similar to lexical decision, lexical familiarity does not necessitate an overt reading response but instead requires patients to indicate which of two words appears more familiar. In addition, familiarity judgments have been commonly used to assess underlying cognition in a number of other patient groups. For example, evaluating memory indirectly through familiarity has demonstrated that despite impaired explicit recall, even severely amnesic patients can learn new information (Bauer, Grande, & Valenstein, 2003; Buckner et al., 1995; Gabrieli, 1998), suggesting that it is a potentially powerful technique for use in patients with overt cognitive impairment.

We had three main goals in this study. Our initial goal was to determine if LOFT performance would be similar across a heterogeneous group of patients diagnosed with aphasia and a comparison sample of patients without language impairments. Second, we aimed to investigate the actual utility of the LOFT in assessing verbally mediated intellectual ability in a group of aphasic patients with a range of expressive and receptive language impairments. More specifically, we sought to determine whether the LOFT would relate to standard and available markers of permorbid abilities, such as education. A final goal was to investigate the relationship of the LOFT to markers of language functioning to determine whether there are aspects of preserved verbally mediated intellectual abilities in patients with aphasia, and whether there are differences across aphasia subtypes (i.e., fluent vs. nonfluent). Our general predictions were that when compared to a traditional measure of oral word reading (the WTAR), the LOFT would be more strongly associated with our criterion variables of premorbid function, and would thus provide a more accurate estimation of verbally mediated IQ in aphasia, as it does not rely on explicit lexical retrieval and expressive output. In addition, we hypothesized that despite significant deficits in expressive and receptive language function, patients with aphasia would

demonstrate preserved access to the aspects of lexical information that support verbal intellectual functioning.

Method

Participants

Aphasic Patients

Thirty-five patients with aphasia were referred to this study through the Harold Goodglass Aphasia Research Center (HGARC) at the VA Boston Healthcare System and Boston University School of Medicine. The HGARC provides recruitment and clinical assessment services to Boston-area aphasia researchers. Patient referrals to the HGARC come from hospitals and rehabilitation facilities in the surrounding areas. Patients are screened for, and excluded on the basis of, a history of significant alcohol or drug abuse, left handedness, significant history of prior psychiatric or neurological disorder or learning disability, or significantly impaired hearing or vision. At the time of testing at the HGARC, the patients in the current study were stable medically and neurologically, were between 21 and 80 years old, were not critically ill, and were not currently receiving any treatment for speech, language, or communication impairments. All participants grew up speaking predominantly American English and completed high school. Thirty-three patients presented with an aphasia resulting from vascular etiology, and two presented with primary progressive aphasia. Mean demographic characteristics of the aphasic group are presented in Table 1.

Table 1. *Demographic Data for Aphasic and Comparison Groups*

	Age		Education		Gender
	M	SD	M	SD	M/F
Aphasic (n = 35)	61.26	10.54	15.23	2.62	27/8
Comparison (n = 125)	64.31	8.83	14.24	2.67	81/44

Note. No significant differences between groups for age or education.

As part of the HGARC clinical assessment, each patient received a comprehensive speech and language evaluation administered by an experienced speech-language pathologist specializing in neurogenic communication disorders. Measures administered included the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass, Kaplan, & Barresi, 2001) and the Boston Naming Test (BNT) (Kaplan, Goodglass, & Weintraub, 2001), both of which are described below.

The BDAE is a comprehensive aphasia assessment tool designed to evaluate a wide range of both expressive and receptive language performance. As part of this assessment, a severity rating score based on objective and subjective performance during the administration of the Boston Diagnostic Aphasia Examination is assigned to all patients. The severity rating scale ranges from “0” (severe, no communication possible) to “5” (mild, minimal discernable speech handicap). Six features of speech production (melodic line, phrase length, articulatory agility, grammatical form, paraphasias in running speech, and word finding), a measure of repetition, and a measure

of auditory comprehension comprise this scale. In the current sample, this rating was assigned to each patient by one of a team of three speech-language pathologists; scores ranged from 0.5 to 4.5. Information from the BDAE is also used to characterize specific aspects of aphasia. Five of the aphasic patients in the current sample presented with a diagnosable motor speech disorder (i.e., dysarthria). To assess reading ability and basic word recognition, we specifically examined scores on the picture-word matching subtest of the BDAE (see Appendix 1). Scores on this subtest were available for 28 of the participants. Based on normative data provided in the BDAE manual (Goodglass, Kaplan, & Barresi, 2001), we considered a score that was 1.5 standard deviations below the mean to be indicative of potential alexia. According to these criteria, 2 of the 28 participants would be classified as having a reading disorder.

The BNT is a confrontation-naming task, containing 60 black and white line drawings, commonly used to obtain a broad assessment of expressive language ability. A correct response is indicated by either correctly providing a name for the item spontaneously, or by correctly providing the name following a stimulus, or semantic cue. Dysarthric responses were not counted as errors if the name of the line drawing was provided correctly. Scores can therefore range from 0 to 60; in the current sample, scores ranged from 0 to 58. Taken together with the range of severity ratings, this range of BNT scores represents an aphasic sample with a broad and varied range of language ability. Linguistic characteristics of the aphasic group are presented in Appendix 1.

Comparison Group

A group of 125 community dwelling, nonbrain-damaged individuals was selected to represent an age, education, and medically comparable sample. This sample contained 75 individuals with one or more cerebrovascular risk factors, such as diabetes or hypertension, but who had no history of stroke or transient ischemic attack, and no history of neurologic disease. These individuals were chosen to be part of the comparison sample because of the fact that in many cases, aphasia with vascular etiology is preceded by risk factors such as the ones represented in this group. In addition, the presence of such factors is known to have a negative effect on aspects of cognition, particularly with regard to executive function (Brady et al., 2001; Hachinski et al., 2006), but the risk factors themselves do not typically result in aphasia. Thus, a sample such as this one containing a likely similar medical and cognitive history provides an ideal comparison, particularly when focusing on a more specific aspect of neuropsychological ability. An additional 50 individuals in the comparison sample had no documented cerebrovascular risk factors and no history of neurological disease or illness, thus representing a neurologically and cerebrovascularly healthy age and education-matched sample. To rule out possible dementia, all participants in the comparison group were administered the Mini-Mental State Examination (MMSE). The MMSE is a brief cognitive screening tool that assesses basic neuropsychological abilities such as attention, orientation, and working memory; scores range from 0 to 30 (Folstein, Folstein, & McHugh, 1975). Participants were included in the comparison sample only if they achieved a score of 24 or above; scores below this number are considered to be indicative of more significant cognitive impairment (Kukull et al., 1994; Monsch et al., 1995). Therefore, this comparison group was thought to be representative of a broad population spectrum containing

community dwelling individuals with comparable ranges of age, education, and risk factors to the aphasic group. Mean demographic characteristics of the comparison group are presented in Table 1.

Stimuli Development

The LOFT was created by pairing each of the 50 items from the Wechsler Test of Adult Reading (Wechsler, 2001) (critical items) with 50 rare, archaic English words (foil items) (see Appendix 2). The WTAR words were chosen because they are a "culture-free" stimuli set for use in English speakers worldwide. In addition, the WTAR has extensive normative data from individuals with wide ranges of age and education, making it a currently popular measure of premorbid verbal intelligence. Archaic words were chosen from a corpus of lexical items (Barnhardt, Glisky, Polster, & Elam, 1996) as foils because of the fact that they represent real English words that are not used in current language, but nonetheless conform to conventional spelling rules and orthographic structure, thus serving as appropriate foil stimuli. In addition, a prior study has empirically confirmed that these words have no associated meaning in current English language (Barnhardt, Glisky, Polster, & Elam, 1996), strengthening the postulation that the WTAR words should emerge as "more familiar" in a testing situation. In past experimental studies, nonwords have also served as appropriate foil stimuli in circumstances where the object is to implicitly assess past experience with a particular lexical item. However, we chose not to use nonwords or pseudowords for a number of reasons. First, nonwords often bear orthographic similarity to real words in current use with known semantic associations (e.g., "zat" for "cat"), and thus, in many cases, can inadvertently activate a real lexical item. Archaic words are unlikely to unintentionally be mistaken for real English words because of their lack of orthographic resemblance to modern English lexical items. In addition, in our piloting of the LOFT task, we found that in patients with aphasia, instructions for making decisions based on familiarity were easier to understand than instructions for making for lexical decisions. Foil items were paired individually to each of the WTAR items and were chosen to be similar in length (number of characters) (LOFT mean letter length = 7.14, SD = 1.69; WTAR mean letter length = 7.84, SD = 2.32) and length in syllables (LOFT mean number of syllables = 2.34, SD = .92; WTAR mean number of syllables = 2.72, SD = 1.20). Analysis of these components revealed no significant difference between the LOFT and WTAR with regard to letter length, $t(98) = -1.73$, $p > .05$ or number of syllables, $t(98) = -1.78$, $p > .05$.

Each item on the LOFT therefore consists of a WTAR item matched with an archaic word, and the WTAR word always serves as the target (correct) response. Placement of target and foil words in each pair (i.e., first vs. second) was equal and randomly varied throughout the test. The entire test consisted of five pages of stimuli pairs (10 pairs per page).

Reliability, or interitem consistency, of the LOFT was assessed in the comparison sample using Cronbach's alpha (Cronbach, 1951). The intraclass correlation coefficient was .929, indicating that the individual items of the LOFT have a high degree of internal consistency. Individual LOFT items were available on a subset of the aphasic patients (n = 18); the intraclass correlation coefficient was .854, providing further support for the fact that LOFT is a reliable measure, even in a sample of brain-damaged individuals.

Procedure

LOFT Administration

The LOFT is a forced-choice recognition test in which participants are asked to select the one word in each pair of target (WTAR) and foil (archaic) words that is the most familiar. Specific instructions for the LOFT are as follows: “Please underline the one word that looks the most familiar to you. If you know both of the words then choose the one that is the most familiar.” Participants were instructed to always make a choice, even if they were unsure, and were allowed as much time as needed to complete the test. Raw score (total number of correctly chosen words) was recorded.

WTAR Administration

Administration of the WTAR followed standard procedures as specified in the WTAR manual (Wechsler, 2001). The WTAR is a standardized word-reading measure on which correct responses are dependent on accurate pronunciation of each word. Examiners are provided with a pronunciation key so that responses can be marked as correct or incorrect immediately during administration. Raw score was recorded and used in subsequent analyses. Participants were always administered the LOFT before the WTAR to reduce the potential of implicit lexical familiarity when completing the LOFT.

Data Analyses

Data were analyzed using the Statistical Package for the Social Sciences, version 13.0 [Statistical Package for the Social Sciences (SPSS), 2006]. We conducted three primary groups of analyses to address our hypotheses. First, to test the hypothesis that there would be group differences on the WTAR but not the LOFT, we conducted two one-way analyses of variance (ANOVA's) for the two dependent measures (WTAR and LOFT), each with one between-subjects variable (Group: aphasic, comparison). We predicted that the aphasic group would demonstrate significantly poorer WTAR scores, but that groups would exhibit statistically similar scores on the LOFT. We then focused analyses on testing the hypothesis that the LOFT is related to additional indices of premorbid functioning; this was done using bivariate correlations within each group separately. We predicted that the LOFT would be related to variables such as education and an additional IQ estimate in both the aphasic and comparison groups. In contrast, we expected the WTAR to be unrelated to these variables in the aphasic, but not comparison group. Finally, we specifically examined the relationship of the LOFT to language variables to test the hypothesis that there are aspects of preserved verbally mediated intellectual abilities in patients with aphasia. This was done in two ways. First, we conducted a series of bivariate and partial correlations. We expected that the LOFT would be related to premorbid variables such as education, independent of variables that directly assess language functioning, and that the WTAR would be more directly related to the severity of the language disorder than the LOFT. As a final analysis to confirm correlation results, we conducted a stepwise regression using raw LOFT score, raw WTAR score, and an index of expressive language functioning (Boston Naming Test) to predict language severity. We expected that the LOFT would not contribute significantly to this model, as we predicted that it would not be related to language severity.

Second, we conducted a mixed factorial ANOVA in the aphasic group with one between-subjects variable (group: “fluent” vs. “nonfluent”) and one within-subjects variable (raw LOFT and raw WTAR score). This was done to support the hypothesis that LOFT performance would be consistent across broad aphasic subtypes.

Results

Table 1 presents mean demographic characteristics for both aphasic and comparison groups. Independent sample *t* tests revealed no significant differences between groups with regard to age and education. Mean MMSE score was 27.60 (*SD* = 2.13) for the comparison group; we are thus fairly confident that our comparison sample is representative of a nondemented group of individuals (Kukull et al., 1994; Monsch et al., 1995). For the aphasic group, average BNT score was 27.24 (*SD* = 22.30; range = 0 to 58) and average severity rating based on the BDAE was 2.49 (*SD* = 1.37; range = 0.5 to 4.5). These clinical data suggest that our patients represent a group of individuals with varying degrees of speech and language difficulties. Of the 35 patients, 14 were classified as “fluent,” 18 were classified as “nonfluent,” and 3 were classified as having “mixed fluency.”

WTAR and LOFT Performance Across Aphasic and Comparison Groups

All analyses were conducted using raw LOFT and WTAR scores, which have a minimum possible score of 0 and a maximum possible score of 50. In the case of the LOFT we also calculated d-prime (*d′*) in an attempt to control for the fact that LOFT scores may contain some degree of guessing, as an individual has an estimated 50% chance of correctly choosing the target word when both words appear to be equally familiar. Previous forced-choice recognition paradigms have adopted a similar approach (e.g., Smith & Duncan, 2004). D-prime is a measure of sensitivity and discriminability commonly used in forced-choice recognition paradigms that takes into account response bias in making decisions, which in the current study, is based on which item on the LOFT is the most familiar. The resulting statistic is a reflection of the sensitivity with which an individual could accurately discriminate between the familiar (WTAR) and unfamiliar (archaic) words in the presence of “background noise.” In the case of the LOFT, this noise refers to guessing, and thus, *d′* is a measure that corrects the total score on the LOFT for the probability on each item that an individual would guess when making a decision. In the current study, *d′* was calculated using traditional signal detection theory methods, where hit rate (correctly identifying a target or WTAR word as familiar) and false alarm rate (incorrectly identifying a foil or archaic word as familiar) are transformed to standardized z-scores and then entered into the following equation: z (proportion of Hits) – z (proportion of False Alarms) = *d′*; this was calculated for each individual's score on the LOFT. An individual's LOFT *d′* score could range from −4.01 (highest probability of guessing) to 4.01 (lowest probability of guessing).

WTAR and LOFT raw scores and *d′* scores for the aphasic and comparison groups are presented in Table 2. Two one-way analyses of variance (ANOVA's) were conducted for the two dependent measures, WTAR and LOFT raw scores, each with one between-subjects factor (Group: aphasic, comparison). There was a main effect of Group indicating a significant difference between groups for the WTAR, $F(1, 161) = 87.86$, $p < .01$ but not the LOFT, $F(1,$

161) = 1.64, $p > .05$. These results indicate that the LOFT produced an estimate of verbal IQ in patients with aphasia that was similar to the estimate of IQ in a comparison group.

Table 2. *WTAR and LOFT Data for Aphasic and Comparison Groups*

	WTAR*		LOFT		LOFT d'	
	M	SD	M	SD	M	SD
Aphasic (n = 35)	15.20	17.59	42.34	6.89	2.30	1.25
Comparison (n = 125)	36.19	10.74	43.63	7.20	2.59	1.29

* $p < .001$ between groups.

Relationship of the WTAR and LOFT to Markers of Premorbid Functioning

Comparison Group

Pearson bivariate correlations were conducted within each group separately to analyze the relationship of the WTAR and the LOFT to each other, as well as to available indices of premorbid ability. A Bonferroni correction procedure was used to adjust for multiple correlations; this was obtained by dividing the value by the number of correlations used to assess premorbid intelligence, which in this group of analyses, was three (WTAR and LOFT, raw score correlated with education; WTAR and LOFT *d′*, score correlated with education); this resulted in a critical *p* value of .017 and a critical *r* value of .27. Within the comparison group, WTAR and LOFT scores (raw and *d′*) were significantly correlated with each other (WTAR and LOFT raw $r = .83$; WTAR and LOFT $d' = .87$). This indicates that in a group with no severe cognitive impairments, the LOFT is providing a similar estimate of premorbid functioning as is the WTAR. WTAR score was significantly correlated with education ($r = .67$). Importantly, LOFT scores were also significantly related to education (LOFT raw: $r = .50$, LOFT *d′*: $r = .54$), a demographic variable that is considered to be a reliable index of premorbid functioning.

Aphasic Group

Pearson bivariate correlations were conducted in the aphasic group, to determine the relationships among the WTAR, LOFT, and education. Correlations were run separately using LOFT raw score and LOFT *d′* score. As with the comparison group, a Bonferroni correction procedure adjusting for the number of correlations (three) was used, resulting in a critical *p* value of .017 and a critical *r* value of .44. Correlations were significant between WTAR and LOFT raw score ($r = .55$) and between the WTAR and LOFT *d′* ($r = .76$). While both LOFT indices correlated significantly with years of education (raw LOFT: $r = .47$; *d′*: $r = .54$), WTAR raw score did not ($r = .32$). In general, more years of education were associated with a higher LOFT score and a higher *d′* score (i.e., better discriminability and less potential guessing).

In an effort to further validate the relationship of the LOFT to premorbid functioning, we computed an additional premorbid intelligence estimate in the aphasic group using a validated formula that takes into account education, as well as age, occupation, sex, and region (Barona, Reynolds, & Chastain, 1984). The Barona equation is widely used as an alternative method of

estimating premorbid ability, and has been validated in several clinical populations (McCarthy et al., 2003). The resulting average Barona full scale IQ (FSIQ) in our sample was 115.35 (*SD* = 5.04), with a range of 106.50 to 121.13. An additional correlation analysis was then conducted comparing LOFT raw score and WTAR raw score with the Barona index, and this same analysis was repeated using LOFT *d′* score. A Bonferroni correction procedure, adjusting for two total correlations in each analysis, resulted in a critical *p* value of .025 and a critical *r* value of .39. Not surprisingly, correlation analyses were similar to those conducted when using education alone. We found that Barona FSIQ was significantly correlated with LOFT *d′* score (*r* = .39), but not with WTAR score (*r* = .06). LOFT raw score was nearly significant (*r* = .33). These results strengthen the argument that in a sample of patients with significant language impairments, the LOFT is more strongly related than the WTAR to premorbid functioning than a traditional word-reading measure.

Relationship of WTAR and LOFT to Language Variables in the Aphasic Group

A final set of analyses focused on examining the relationship of WTAR and LOFT performance to specific linguistic aspects of the aphasic group; namely lexical retrieval (as assessed with BNT), aphasia severity rating (as assessed by BDAE), and fluency (i.e., nonfluent vs. fluent). Number of correlations (LOFT raw score, LOFT *d′* and WTAR score each compared with BNT and then with severity rating) was adjusted using a Bonferroni correction procedure; the critical significance level was set at .017 and the resulting critical *r* value was .44. BNT score was significantly related to WTAR raw score (*r* = .73), LOFT raw score (*r* = .65), and LOFT *d′* (*r* = .68). Analyses focused on severity rating also correlated significantly with all three scores (WTAR: *r* = .75; LOFT raw: *r* = .55; LOFT *d′*: *r* = .55).

Effect of lexical retrieval

While performance on both the WTAR and the LOFT are to some degree related to expressive language ability (evidenced by their significant relationships with BNT score), we hypothesized that specific linguistic characteristics such as phonological retrieval and articulation are a more critical component of the WTAR than they are of the LOFT. This is based on our assumption that the ability to directly retrieve and articulate a lexical item is not an obligatory aspect of the LOFT. The Boston Naming Test is a standard measure of word retrieval that has been used as a reliable index of expressive language function (Kaplan, Goodglass, & Weintraub, 2001). Therefore, we conducted partial correlations between WTAR or LOFT scores (including raw LOFT and *d′*) and education level while controlling for BNT score. A Bonferroni correction procedure, adjusting for two total correlations in each analysis, resulted in a critical significance level of .025 and a critical *r* value of .39. These analyses revealed both LOFT *d′* score (*r* = .51) and LOFT raw score (*r* = .42) to be significantly correlated with education. The correlation between WTAR raw score and education continued to emerge as nonsignificant (*r* = .15). This suggests that in patients with language deficits, the LOFT is a more accurate reflection of premorbid ability, and is likely more closely related to verbal IQ than the WTAR.

Effect of aphasia severity rating

We then conducted partial correlations, controlling for BNT score, to examine the relationship of the LOFT and WTAR to severity rating when removing the variance associated with speech output. The critical *p* value was again set at .025 (adjusting for two total correlations in each analysis) while the critical *r* value was set to .45. Both LOFT scores were no longer associated with severity rating (LOFT raw: $r = .14$; LOFT d': $r = .01$), while the WTAR continued to correlate significantly ($r = .45$). Lower WTAR scores were associated with more severe severity rating score. This indicates that while performance on the LOFT is related in some degree to word-finding or language production in general, it is unrelated once variation because of these aspects of language is removed. Performance on the WTAR, in contrast, is more strongly related to the severity of the language disorder, even when the contribution associated with speech output is factored out of analyses.

As a final analysis to confirm these results, a stepwise regression analysis was conducted with LOFT raw score, WTAR raw score, and BNT score as independent variables, and with severity rating as the dependent variable. As expected, BNT score and WTAR scores emerged as significant predictors (BNT: $t = 3.58$, $p < .01$; WTAR: $t = 2.79$, $p < .01$), whereas raw LOFT score was removed from the equation. Note that the R^2 was .71, indicating that this is a highly predictive model. These regression findings strengthen our previously reported correlation results, and support the conclusion that in contrast to the WTAR, performance on the LOFT does not independently contribute a significant amount of variance to severity ratings. Regression results are presented in Table 3.

Table 3. *Summary of Stepwise Regression Analysis Predicting Severity Rating From Boston Naming Test and WTAR Raw Score in the Aphasic Group (N = 35)*

Predictors	B	SE B	Beta
BNT score	.003	.009	.508
WTAR raw score	.003	.011	.396

Note. $R2^2$ =.71; LOFT: Beta in = .059, t = .449, p = .656.

Effect of fluency

Mean WTAR, LOFT and linguistic data for fluent and nonfluent groups are presented in Appendix 1. Fluent patients tend to have fewer articulatory or speech initiation problems than nonfluent, but often suffer from more apparent problems with comprehension and paraphasias (Goodglass, Kaplan, & Barresi, 2001). Nonfluent patients tend to produce shorter utterances with greater articulatory difficulty than fluent patients and are more likely to suffer from dysarthria than patients with fluent aphasias (Goodglass, Kaplan, & Barresi, 2001). Presumably, if performance on the LOFT is independent of aspects of language that are differentially affected by fluent and nonfluent aphasia, then there should be no differences in performance across groups. We conducted a mixed factorial ANOVA with LOFT and WTAR raw score between the fluent ($n = 14$) and nonfluent ($n = 18$) aphasics. The three "mixed fluency" cases were excluded for the purpose of this particular analysis. Results revealed a main effect of test, $F(1, 30) = 93.46$, $p < .001$; LOFT scores were significantly higher than WTAR scores for both groups. The

main effect of group was not significant, $F(1, 30) = 2.84$, $p > .05$, nor was the interaction between group and test, $F(1, 30) = .856$, $p > .05$. These findings support the argument that the distinction between the LOFT and the WTAR is consistent across general classifications of aphasia, and that performance on the LOFT is not differentially affected by symptomatology characteristics of either group, such as verbal agility and articulatory deficits (commonly seen in nonfluent aphasia), or comprehension and expressive difficulty (commonly seen in fluent aphasia).

Discussion

The primary finding from this study was the clear difference in aphasics' ability to orally read irregular words compared to their ability to make accurate lexical familiarity judgments of the same words when included in a forced-choice decision paradigm. This was in contrast to the comparison group who did not show such a performance difference. Second, and perhaps most critically, oral word reading (as indexed by the WTAR) and lexical familiarity judgments (as indexed by the LOFT) were both related to education in the comparison group, but only the LOFT showed this expected relationship (as well as to a statistically derived demographic formula) in the group of aphasics. The WTAR, but not the LOFT, also continued to show strong relationships with severity of aphasic symptoms when partialing out BNT score. Thus, this study has established that the LOFT is a potentially valid index of verbal intellectual abilities in a nonbrain damaged adult sample when compared to current standards, and that its validity is maintained in the face of acquired language disorders. Not only does this demonstrate the utility of a word-recognition paradigm in estimating premorbid intelligence, but our results also provide evidence of implicit access to lexical items in patients with a variety of linguistic processing difficulties.

One of the most interesting findings came from examination of the relationship of the LOFT and WTAR to various aspects of language functioning. These analyses showed that a significant portion of the variance of the LOFT was not related to the severity or types of language symptoms. LOFT and WTAR scores correlated significantly with aphasia severity rating, but only the LOFT was *not significantly correlated* with severity when controlling for a measure of lexical retrieval (BNT score), indicating that when variance associated with a naming task is removed, the *residual* variance of the WTAR, but not the LOFT, continues to be related to aphasia severity, and therefore implying that the WTAR is much more dependent on linguistic processes affected by aphasia. This conclusion is supported by the fact that the WTAR and BNT, but not the LOFT, were predictors of severity rating in a supplemental regression analysis. Taken together, these analyses raise the possibility that LOFT performance is determined by both a lexical *familiarity* component and what can be referred to at least heuristically as a *nonfamiliarity* component; the latter of which is more directly related to language performance. Under this view, we would hypothesize that the “familiarity” component is dependent on and sensitive to word exposure over the course of an individual's lifetime. The extent to which this exposure included increasingly low frequency words is likely to be related in some way to premorbid verbal intelligence. In contrast, we would speculate that the “nonfamiliarity” component (though not operating totally exclusive of familiarity) is more dependent on lexical

access or lexical retrieval and therefore more affected by the presence of aphasic symptoms, thus mitigating its sensitivity to premorbid intellectual abilities. Removing the variance associated with the BNT from raw LOFT score therefore provided a purer assessment of the relationship between word familiarity (and premorbid verbal abilities) and indices of general premorbid function, demonstrating that the LOFT can be completed, though not obligatorily, without phonological retrieval and articulation. In contrast, the WTAR cannot be performed using lexical familiarity alone and therefore in the face of ensuing aphasic symptoms, is no longer predictive of markers of premorbid intellectual ability. A number of psycholinguistic models of word processing support this distinction between lexical retrieval and lexical familiarity. For example, word recognition is hypothesized to be based on orthographic familiarity as well as word frequency (Grainger & Jacobs, 1996), and can also be achieved without phonological retrieval and articulation, as suggested by connectionist models of word reading (Seidenberg & McClelland, 1989). The LOFT capitalizes on these principles.

The fact that LOFT performance was relatively resistant to language severity in a fairly heterogeneous sample of patients with acquired language disorders has important theoretical implications, as it suggests that aphasic patients can access specific aspects of lexical knowledge under certain conditions. As such, we offer several distinct yet hypothetically related explanations. First, it is possible that expressive symptoms of aphasia that impact WTAR performance (such as anomia, paraphasias, and nonfluency) stem from impaired access to the underlying lexical representations, as opposed to disruptions to the lexical networks themselves. This idea is consistent with prior studies demonstrating implicit activation of lexical-semantic and lexical-orthographic information (Friedman, 1981; Milberg & Blumstein, 1981; Mimura, Goodglass, & Milberg, 1996). Second, it is also possible that word familiarity judgments may be made on the basis of partial lexical information still existing in lexical networks, and tasks that are more sensitive to the integrity of these networks (such as word retrieval) are therefore more difficult. This idea is rooted in connectionist theories that have explained specific cognitive deficits as a disruption to *aspects* of neurocognitive networks, as opposed to the entire network per se (McClelland & Plaut, 1993). An additional explanation for the fact that the LOFT was relatively resistant to aphasia severity is the possibility that the system upon which familiarity judgments depend is in a sense a low-level memory system that retains evidence of lifelong exposure and perhaps use of orthographic or lexical information.

Another issue that these results potentially address is that of the status of verbally mediated intelligence in patients with aphasia, an issue that has received little empirical attention in the literature. Primarily because of patients' expressive language difficulties, past attempts to characterize intellectual functioning in language-disordered individuals have focused almost exclusively on nonverbal measures with no attempt to directly measure what may have been preserved verbal intelligence. For example, in an early discussion of this issue, Zangwill (1964) reported that on a task of nonverbal intelligence, severe aphasic patients performed within normal limits, despite impaired performance in several other cognitive domains (Zangwill, 1964). Although there are reported cases of “impaired” intelligence (Loddenkemper et al., 2004), this predominant finding has been replicated, even across various subtypes of aphasia (Kertesz & Mccabe, 1975). Together, these findings have led many to conclude that nonverbal aspects of

intelligence may be preserved in patients with significant language disorders (Kertesz & Mccabe, 1975), but that aphasia impairs verbal intellectual functioning (Lafavor & Brundage, 2000). The current results raise the possibility that some aspects of verbally mediated intelligence may still be preserved in patients whose instrumental linguistic competence has been compromised. This in turn may be useful in understanding the theoretical relationship between verbal intelligence and the linguistic functions that are commonly affected in aphasia.

The idea that we can accurately estimate premorbid IQ in individuals with aphasia also has clinical and practical implications, especially when considering the fact that aspects of intelligence, such as word knowledge, are resistant to the effects of neurologic injury (Stebbins, 1998). Over the past several years, the concept of cognitive, or neural reserve has been the focus of many studies investigating outcome and progression in disorders such as dementia, with the general finding that certain premorbid aspects of neuropsychological or intellectual functioning may serve as protective factors against neurologic disease as well as general cognitive decline (Barnett, Salmond, Jones, & Sahakian, 2006; Corral et al., 2006). In fact, several studies have reported that recently diagnosed dementia patients with high average baseline intellectual functioning have a delayed age of onset in addition to a more favorable prognosis when compared to individuals with lower estimated premorbid function levels (Rentz et al., 2000, 2004). Premorbid intelligence has also demonstrated utility in predicting both cognitive and functional outcome in rehabilitation settings. For example, prior studies have found that when compared with lower premorbid IQ, higher estimated premorbid functioning may lower susceptibility to cognitive changes after traumatic brain injury (Kesler, Adams, Blasey, & Bigler, 2003). Thus, more precise knowledge of premorbid function can offer essential information to be used in treatment planning, in structuring appropriate rehabilitation strategies, and in predicting outcome. In aphasia, treatment of language difficulties is often a central component to poststroke regimens, and more specific knowledge of verbal premorbid functioning may prove to be a vital factor predicting the success of a particular approach.

One potential limitation of this study relates to the primary criteria used for validation of the LOFT. We reasoned that the WTAR, with its extensive normative data, would be able to provide estimates of premorbid IQ across a broad range of premorbid abilities in the healthy comparison sample. The fact that LOFT and WTAR scores were similar in this nonbrain-damaged group supports this assumption. However, because of limited psychometric information on verbal intelligence, we did not have such a direct measure of IQ in the patients with aphasia, especially since we expected WTAR scores to be impaired. Thus, we made the assumption that education level and a statistically based demographic formula would make adequate, but not complete substitutes for premorbid IQ estimation. We recognize that by itself, education does not define IQ, but is nonetheless significantly related to premorbid function, as evidenced by its high correlations with existing intelligence measures (Wechsler, 2001). In the current study, we also have evidence that LOFT scores are highly correlated with *both* of these criterion variables in the aphasic group, strengthening the argument that to the extent to which education and a combination of education, occupation, age, and race are related to premorbid IQ, verbal intellectual abilities appear to be relatively preserved in aphasia.

Additional limitations include the fact that the LOFT may underestimate premorbid IQ in patients with more severe global aphasia. For example, the fact that several of our participants achieved low enough scores on the BDAE word recognition subtest to be classified as alexic raises the question of whether this affected their ability to reliably complete the LOFT. Inspection of these individual scores (see Appendix 1) reveals that those individuals with lower word recognition scores also had moderate to severe severity ratings and low BNT scores, raising the possibility that they are globally aphasic. As such, their LOFT scores are also somewhat lower than what would be expected based on education level alone. However, it is important to point out that the lower LOFT scores are still considerably higher than the WTAR score and are thus, we would argue, still providing a more accurate estimation of premorbid IQ. The fact that our sample represents a wide range of linguistic abilities is a significant strength, and suggests that the LOFT may be appropriate even for individuals with more severe aphasic symptoms. As more data are collected, the residual relationship to severity level may be adjusted statistically.

There was also a fairly narrow range of education in our sample. However, in this initial study, our primary goal was to develop an instrument that was capable of estimating premorbid verbal IQ in patients with varying degrees of language disorders. Our intentions were not to explore all psychometric properties of the LOFT, and the current sample was therefore not selected in a way that would allow this. Nonetheless, the strong relationship of the LOFT to education in both samples, and additionally to the Barona estimate in the aphasic group, clearly demonstrates that to the extent to which demographic variables such as education are related to premorbid IQ, verbal intellectual abilities appear to be relatively preserved in aphasia. Future goals therefore include examining the LOFT in populations with better characterization of IQ and particularly, in patients with more severe cognitive impairments such as those commonly seen in dementia.

In summary, we present data supporting the reliability and validity of an instrument based on lexical and orthographic familiarity judgments as a measure of verbally mediated IQ in patients with aphasia and healthy controls. Furthermore, the measure seems to provide these estimates across a range of expressive and receptive language deficits, indicating that the LOFT may be useful in a wide variety of cases. Based solely on our results, it is not entirely clear whether LOFT performance reflects a residue of premorbid intellectual functioning, current intelligence, or both. However, our data suggest that patients with language impairments can still access aspects of lexical information that additionally may provide insights into premorbid verbal intellectual abilities.

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APPENDIX

APPENDIX A: Individual Data for Aphasic Patients

Table A1. *Individual Data for Aphasic Patients*

	Age	Education	BNT score	BDAE reading score	Severity rating	LOFT score	WTAR score	LOFT d’
Nonfluent								
1	68	16	0	3	.50	34	0	.88
2	66	12	44	8	4.00	33	0	.77
3	70	12	1	9	1.00	34	0	.88
4	44	12	8	9	1.00	35	0	.99
5	55	16	46	10	2.00	48	0	3.31
6	77	12	0	8	1.00	35	0	.99
7	54	16	0	7	1.00	36	0	1.11
8	45	13	0	*	1.00	28	0	.25
9	53	12	0	5	.50	28	0	.25
10	70	18	0	*	1.00	31	0	.56
11	58	20	9	7	1.00	48	0	3.31
12	66	12	49	10	3.50	43	18	2.07
13	51	18	54	10	2.50	50	18	4.01
14	53	18	52	10	4.00	48	30	3.31
15	62	16	55	10	4.00	50	34	4.01
16	62	16	58	10	4.00	49	43	3.80
17	77	18	53	10	3.50	50	44	4.01
18	65	16	27	10	2.00	43	25	2.07
Mean (SD)	61.57 (11.25)	15.19 (2.52)	25.33 (24.96)	16.21 (12.94)	2.08 (1.37)	39.76 (7.64)	10.90 (15.66)	1.92 (1.36)
Fluent								
1	58	16	25	10	3.50	41	0	1.76
2	55	16	1	10	2.00	44	0	2.26
3	78	16	28	10	2.00	50	0	4.01
4	60	12	32	10	3.50	44	0	2.26
5	70	16	3	*	2.00	44	0	2.26
6	66	14	37	10	1.00	35	16	.99
7	65	16	47	8	4.50	47	34	2.96
8	60	12	14	*	4.00	44	40	2.26
9	61	20	43	10	4.00	50	42	4.01
10	27	17	45	7	4.50	39	43	1.48

11	80	18	58	*	4.50	50	48	4.01
12	61	12	*	*	1.00	45	16	2.46
13	53	12	55	8	4.00	47	34	2.96
14	62	13	16	*	1.00	45	16	1.61
Mean (SD)	61.14 (12.53)	15.00 (2.54)	31.08 (18.67)	25.18 (10.09)	3.11 (1.27)	44.29 (4.45)	20.86 (18.84)	2.52 (.97)
Mixed								
1	62	12	0	10	1.00	46	0	2.69
2	70	16	16	8	2.00	43	0	2.07
3	60	20	50	10	3.00	50	28	4.01

*Data not available.

Table A2. *Foil Items for the LOFT*

1. aglet	11. fleam	21. chiliad	31. colubrine	41. sapidity
2. buccula	12. cadge	22. bibble	32. upeygan	42. shoggle
3. bilch	13. kibe	23. fugacious	33. proxenate	43. lythcoop
4. curtate	14. sinapize	24. burgonet	34. paletot	44. couvades
5. brichins	15. buldgering	25. foulcher	35. auricome	45. brisance
6. cark	16. drecche	26. hystricine	36. emunctory	46. brumous
7. rampelter	17. thew	27. votary	37. cere	47. chewink
8. syrt	18. gelogenic	28. napery	38. fuscous	48. hucksome
9. krang	19. elrig	29. repkie	39. anicular	49. accipiter
10. anchoret	20. gumpelfik	30. grignet	40. popliteal	50. minatory

Note. In the LOFT, each foil item is paired with a word from the WTAR as they appear in the published WTAR manual.