3. Pronunciation of low-frequency irregular words in estimating premorbid intelligence

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Abstract

Recently, McGurn et al. (2004) confirmed that the pronunciation of the low frequency and irregular words in the National Adult Reading Test (NART) is preserved in adult patients with dementia and NART provides a good estimate of premorbid intelligence of these patients. We attempted to answer these intriguing questions by examining the phonological structure of NART words, particularly the optimality of the demisyllables constituting these words. Following Clement (1990), we found the initial and final demisyllables of NART words are near optimal in sonority dispersion as compared with some regularly spelled counterparts. The near optimality of NART words may facilitate their retrieval and become part of "crystallized intelligence". We further invoked the concept of word reading as paired-associate learning to explain the unique visual-verbal contribution to irregular word reading. We speculated that the pronunciation of NART-like low frequency Japanese kanji words or Chinese characters with optimal speech forms may also be preserved in Japanese or Chinese dementia patients and may correlate with premorbid intelligence.

Key words: National Adult Reading Test (NART), optimality of demisyllables, phonological structure of NART words, premorbid intelligence in dementia, word reading as paired-associate learning,

1. Introduction

It is no exaggeration to say that Professor Takeshi Hatta has played an important leadership role in the development of psychology as an academic discipline in Japan these thirty years. We have no doubt that he will continue to do so. It is a privilege and an honor for both authors to be asked to contribute a paper to help celebrate Professor Hatta's Sixtieth Birthday. Rather than writing just a congratulatory message, we thought it more meaningful to append a small note on our reactions to a paper on estimating premorbid intelligence in adult patients from low-frequency irregular words in English from the well-known National Adult Reading Test (Nelson, 1991). The phenomenon puzzles us and other researchers (e.g., Detterman, 2004). We feel the topic in an area of neuropsychology reflects part of the many interests and contributions of Professor Hatta and hope our note will promote further debate and research among colleagues.

Many complimentary remarks can be made about the important achievements of Takeshi Hatta. Suffice it to state his research interests are many and varied: The processing of Japanese kanji and kana, functional cerebral laterality and more recently organizational psychology of which he is the founder and Editor-in-Chief of the *Journal of Human Environmental Studies*.

One of the authors (CKL) first met Takeshi at a Chinese/Asian Language conference in Hong Kong in the early 1980s or late 1970s. Takeshi and CK subsequently met a number of times on similar occasions and also during CK's visit to his neuropsychology lab at Osaka University of Education. It was where he conducted many of his visual-half field studies and CK at that time was interested in the auditory counterpart of dichotic listening experiments, both techniques being used to infer functional cerebral laterality. These behavioral studies using visual-half fields and dichotic listening paradigms were long before the days of fMRI, ERP and other neurobiological studies of the brain. CK was amazed that the number of papers that Takeshi published in prestigious journals such as Cortex relied on just one tachistoscope! This goes to show that research is the product of hard work, good ideas, asking the right questions and of course sophisticated instrumentation helps and often is essential these days.

Takeshi simply goes ahead and does what he considers to be right, to help promote the field of psychology and to mentor young scholars. The founding of the *Journal of Human Environmental Studies* is a case in point when he saw the need several years ago and had the courage and tenacity to start the Journal from scratch. Now it is going into the sixth year of publication and by all accounts is thriving. May we wish Takeshi many years of equally productive research and writing for the benefit of psychology and the younger generation of scholars and researchers. On a personal note we also wish Takeshi and Setsuko Hatta many years of longevity and happiness.

2. Estimating pre-morbid intelligence from NART

We now wish to append this small note on clinical neuropsychology by way of sharing our puzzlement. It was the second author (JY) who first raised the issue on reading the paper by McGurn, Starr, Topfer, Pattie, Whiteman, Lemmon et al. (2004) on estimating intelligence in patients with dementia from the National Adult Reading Test (NART) and it was JY who did much of the cooperative work. NART is "specifically designed to provide a means of estimating the premorbid intelligence levels of adult patients suspected of suffering from intellectual deterioration" (Nelson, 1991, p.1; Ryan & Paolo, 1992). The NART has also been adapted for North American population as North American Adult Reading Test (NAART or NART-R) (Blair & Spreen, 1989; see also Spreen & Strauss, 1998).

Since its early version (Nelson & O'Connell, 1978) NART has been shown to be a reasonably good indicator of premorbid intellectual ability. It has also been shown that in moderate to severe levels of dementia there is a deterioration in NART performance (Patterson, Graham, & Hodges, 1994), and NART performance is influenced by severity of dementia (Taylor, 1999). The reading test also tends to underestimate the intelligence levels of patients with mild dementia with some accompanying linguistic deficits (Stebbins, Gilley, Wilson, Bernard, & Fox, 1990). Recently, McGurn et al. (2004) demonstrated that the correlation between NART scores at about age 80 and IQ at age 11 was similar in people with and without dementia, thereby further confirming that the NART

(composed of low-frequency irregular words such as *aisle*, *psalm*, *campanile*) can be used to estimate premorbid intellectual ability in dementia. When controlling for age 11 IQ scores, mean NART scores did not differ in healthy and demented people, thus demonstrating the utility of NART as an instrument in the assessment of cognitive impairment in adult patients.

This finding by McGurn et al. (2004) is intriguing because all of the NART test words are irregular words and most are low-frequency words. Puzzling questions as posed by Detterman (2004) thus remain as to: (1) Why pronunciation of irregular words is preserved in dementia and (2) Why it is highly correlated with premorbid intelligence. We attempt to answer these vexing questions by examining some psycholinguistic characteristics of the NART words.

3. Method

The NART words appear to have at least three important psycholinguistic characteristics: (1) All the words are relatively short, mostly one to three syllables in length, (2) Most are low-frequency words, and (3) Most appear to be relatively easier to learn due to their phonological quality. The first is a characteristic feature of this test which was specifically designed "to avoid the possible adverse effects of stimulus complexity on the reading of dementing subjects" (Nelson, 1991, p. 2). The second can easily be verified by utilizing the Carroll, Davis, and Richman (1971) corpus, which has some 87,000 word types from about 5,000,000 graphic words of running text, and the Francis and Kučera (1982) corpus, which is based on about 1,000,000 graphic words of running text.

The third question involves word learning and processing, and needs some psycholinguistic explanation. Learning to read words, especially irregular (or exception) words, can be taken as a special case of paired-associate learning (Hulme, Goetz, Gooch, Adams, & Snowling, 2007; Treiman & Baron, 1983). In the case of irregular words used in the NART, one may well pay attention to the orthographic complexity of the stimulus items, e.g., *ache* and *thyme*, but the paired-associate learning theory suggests that the familiarity, meaningfulness, and pronounceability of the response items, i.e., /eik/ and /taim/, are far

more important (Underwood & Schulz, 1960). Given this hypothesis, the question to ask is if most of the 50 NART words consist of easier words then one may imagine if the phonological cues of these words are generally optimal in terms of phonological structure. We thus attempted to measure the quality of the phonology of the NART words.

One way to measure such quality is to examine the degree of optimality of syllables, demisyllables in particular, which compose the NART words. Given a syllable CCCVCCC, where C designates a consonant and V a vowel, a demisyllable is defined as CCCV or VCCC, i.e., a maximal sequence of tautosyllabic segments of the form containing a vowel V. Clement (1990) formulated the Sonority Dispersion Principle to show the degree of distance from the optimal syllable based on the Core Syllabification Principle. The Core Syllabification Principle states, "Given P (an unsyllabified segment) adjacent to Q (a syllabified segment), if P is lower in sonority rank than Q, adjoin it to the syllable containing Q (iterative)" (Clement, 1990, p. 317). A measure of dispersion D of the distances in sonority rank d between the pairs of segments in a demisyllable is defined as:

$$D = \sum_{i=1}^{m} \frac{1}{d_i^2},$$

where d_i is the distance in sonority rank between each ith pair of segments in the demisyllable, and m is the number of pairs in the demisyllable. The well-formedness of a syllable is indicated by D values such that for the initial demisyllable, the smaller the D value is, the more optimal it is, and for the final demisyllable, the larger the value is, the more optimal it is.

All the D values of basic demisyllables are available in Clement. We used these values to show how optimal the demisyllables of the NART words are. For example, the word *thyme* /taym/ is composed of the initial demisyllable /ta/ OV and the final demisyllable /aym/ VGN, where O designates an obstruent, G a glide, and N a nasal, and the D for the initial demisyllable is 0.06 and that for the final is 1.36. These values indicate that both the initial and final demisyllable are near optimal. Our working hypothesis is that the demisyllables of the NART words may be better than those of their regularly spelled counterparts.

Since word frequency is considered a critical variable which affects lexical learning and processing, we could use words whose frequencies are comparable to the frequencies of the NART words as control words. Specifically, controlling for number of syllables and parts of speech, we chose two words per one NART word, which are ranked around the NART word in the Carroll et al. (1971) word frequency rank list. (The rank list of the Francis & Kučera corpus is too short to be useful; so is that of the British National Corpus (Leech, Rayson, & Wilson, 2001). As an example, the NART word *psalm* with a frequency of 6 has a D value for the initial demisyllable of .06 and a D value for the final demisyllable of .11. The two control words with comparable frequency are: *pep* with a frequency of 8 and a D value for the initial demisyllable of .06 and a D value for the final demisyllable of .06; and *throb* with a frequency of 6 and a D value for the initial demisyllable of .56 and a D value of the final demisyllable of .06.

4. Results

The first finding was that the NART words by and large consisted of low-frequency or very rare words. Of the 50 NART words, only 20 words (27 words if derived forms included) were found in the Carroll et al. (1971) corpus. The mean printed frequency of these 20 words were 29.1 but if the "outlier" first word "chord" with a frequency of 303 was excluded the frequency of the remaining 19 words dropped to 14.68. Similarly, 30 words were found in the Francis and Kučera (1982) corpus, and there were 19 words whose frequency counts were more than one.

With regard to the quality of phonological structure of the NART words, results were not straightforward because of the rarity of many of the words. We had 18 words out of the 50 for which we could adequately select control words from the Carroll et al. corpus and then compared their mean D values. Table 1 shows the main results.

The mean D value of the initial demisyllables of the first syllables tended to be smaller for the NART words ($M = 0.22$) than for the controls ($M = 0.38$), t (17) = 1.67, $p < .06$ (one-tailed), and the mean D value of the final demisyllables

Table 1: Mean D values (*SD*s) of the initial and final demisyllables for the NART and control words

	NART words	Controlled words
1st syllable (n = 18)		
Initial	0.22 (0.35)	0.38 (0.36)
Final	1.33 (0.71)	0.55 (0.61)
2nd syllable (n = 8)		
Initial	0.26 (0.37)	0.32 (0.35)
Final	0.89 (0.36)	0.62 (0.47)
3rd syllable (n = 1)		
Initial	0.25 (0)	1.00 (0.43)
Final	1.00 (0)	0.62 (0.44)

of the first syllables was significantly larger for the NART words (M = 1.33) than for the controls (M = 0.55), t (17) = 4.62, $p < .0001$ (one-tailed), thereby suggesting that the first syllables of the NART words are phonologically more optimal than those of the controls. (Note that 9 of the 18 words were monosyllabic words which also exhibited essentially the same tendency.)

For the remaining 32 rare words, the mean D values were 0.39 (SD = 0.41) and 0.80 (SD = 0.48) for the initial and final demisyllables of the first syllables (n = 32); 0.39 (SD = 0.43) and 0.59 (SD = 0.45) for the second syllables (n = 29); 0.39 (SD = 0.41) and 0.80 (SD = 0.58) for the third syllables (n = 17); and 0.49 (SD = 0.44) and 0.63 (SD = 0.43) for the fourth syllables (n = 7), respectively. These values were comparable to those of low-frequency control words (see Table 1).

5. Discussion

We have shown the following. (1) Most of the NART words are relatively short (29 of the 50 words with 6 letters or less) and of very low-frequency (20 words with available printed frequency from Carroll et al., 1971, average 29.1 or 14.68 after excluding the outlier word "chord"). (2) Although the orthographic

forms of the NART words appear very complicated, their phonological structure is rather better-formed than that of their regularly spelled counterparts. These findings certainly allow for several interpretations. The interpretation we prefer is the following.

Learning to read these NART words should not be very difficult following the principle of paired-associate learning which states that the more pronounceable the response item is, the easier the paired-associate learning becomes (Underwood & Schulz, 1960). Consistent with this notion is the recent study by Hulme, Goetz, Gooch, Adams, and Snowling (2007) from two experiments examining three paired-associate tasks (visual-verbal, visual-visual, and verbal-verbal) in single word, nonword reading and phonemic awareness in seven- to eleven-old typical readers. Of particular relevance to our study is the finding that the cross-modal visual-verbal paired-associate learning, compared with the within-mode pair-associate learning, contributed unique variance to irregular word reading and single word reading. Together with phonemic awareness, visual-verbal associate learning was shown to play an important role in learning to read. The plausible explanation is that the cross-modal visual-verbal paired-associate learning requires memory representation of graphemic shapes and thus adds another component in learning to read in addition to phonemic awareness. This cross-modal learning goes beyond the learning of visual or phonological representation in relation to reading (Hulme et al., 2007).

Why is pronunciation of low-frequency irregular words preserved in dementia? It is plausible that once relatively easy written words have been acquired, they become part of "crystallized intelligence" which is difficult to lose (Horn & Cattell, 1967). These crystallized words are easily retrieved especially when the first syllables are phonologically optimal. We add here that the importance of word-initial speech-sound cues has been shown to help both aphasic patients (Goodglass, 1980) and normal people (Goodglass & Wingfield, 1997) in retrieving or naming words, and that crystallized words such as the NART words are less vulnerable not only to age changes but also to dementia, aphasia, and normal TOT (tip-of-the-tongue) phenomena. It is also possible that the semantic memory system which is critical to reading exception words

is only partially impaired in patients with mild and moderate dementia, thus making the oral reading of NART words less vulnerable to impairment (Patterson, Graham, & Hodges, 1994).

Secondly, why does pronunciation of irregular words correlate highly with premorbid intelligence? We propose that it is not because the ability to read irregular words is inherently associated with intelligence. It is because reading ability, reading experience, and intelligence are highly correlated with one another and thus the ability to read irregular words is correlated with intelligence via reading experience which helps readers learn low-frequency or rare words such as the NART words. The learnt words are soon preserved in the readers' mental lexicon.

Although this second conclusion may strike us as less dramatic, it would not invalidate the NART as a tool to assess demented and possibly alexic patients' premorbid intelligence. We need to examine more rigorously the limitations and possibilities of the NART, however. For example, we did not examine imageability of the NART words where the orthography to phonology mapping is not strong. There is evidence of interaction between imageability and regularity where imageability facilitates the naming of low-frequency words (Strain & Herdman, 1999). However, our close observations suggest that many of the NART words have moderate imageability values. If such is the case, that would also be a contributing factor to the learning and processing of the words in childhood and adolescence. There are also doubts about the validity of the NART as a comparator of premorbid functioning in dementia even though its usefulness in estimating the lower limit of premorbid IQ is recognized (Beardsall & Huppert, 1997; Stebbins et al., 1990). To remedy this, there is the suggestion that NART should be used in conjunction with demographic information such as education, age, ethnicity and occupation to booster its effectiveness (Spreen & Strauss, 1998).

Also of interest is the generality of the NART. Specifically, we ask if the NART may be translated into or adapted for non-alphabetic writing systems such as the Japanese syllabary and the morphosyllabic Chinese, both of which use logographic characters, analogous to irregular words in English. As re-

searchers in reading and psycholinguistics especially in the processing of Japanese kanji and kana and Chinese characters and words (e.g., Leong, Nitta, & Yamada, 2003; Yamada & Leong, 2005) we are keenly interested in this issue. It may turn out that pronunciation of low-frequency kanji words or Chinese characters with optimal speech forms in Japanese, for example, is also preserved in dementia and correlates with premorbid intelligence. This is a worthwhile question for further research.

With the above note and our observations of the estimation of intellectual functioning in patients with dementia from the pronunciation of low-frequency irregular English words, we invite our colleagues to make further observations. Again, we wish Takeshi Hatta many happy returns and many more years of productive academic endeavours.

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Acknowledgement

We gratefully acknowledge the support from the Social Sciences and Humanities Research Council of Canada (CKL) and the Japanese Ministry of Education and Science (JY).

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