Cognitive Neuropsychological and Regional Cerebral Blood Flow Study of a Japanese-English Bilingual Girl with Specific Language Impairment (SLI)

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ABSTRACT

We report here on an investigation into the possible factors which might have contributed to language impairment in EM, a 14-year old Japanese-English bilingual girl. EM was born in the UK to Japanese parents with no other siblings, and used English to communicate with all other people except for her parents. A delay in her English language development was identified at primary school in the UK, which was attributed to her bilingualism. The deficiency in her English language skills persisted into her adolescence despite more than adequate educational opportunities (including additional language support). At the start of her secondary education, language ability/literacy attainment tests were conducted in both English and Japanese, and the results suggested specific language impairment (SLI) in both languages. Further, her brain SPECT (Single Photon Emission Computed Tomography) revealed significantly lower rCBF (Regional Cerebral Blood Flow) in the left temporo-parietal area, which is also similar to the area of dysfunction often found among Japanese individuals with SLI.

INTRODUCTION

Approximately half the children in the world are exposed to more than one language (e.g., de Houwer, 1995). However, the literature on bilingual development is very limited in comparison to the literature on second language learning in terms of both the number of studies reported and the number of subjects per study (Hoff-Ginsberg, 1997). An often addressed question on bilingual development is whether bilingual children demonstrate a developmental delay in each language compared with monolingual children. Some studies have supported the idea that there is a significant developmental language delay in bilingual children (e.g., Rosenblum & Pinker, 1983; Umbel, et al., 1992). For example, Rosenblum and Pinker (1983) found that bilingual children aged five and over had smaller comprehension vocabularies in each of their languages than age-matched monolingual children. However, Pearson, et al.'s (1993) longitudinal study following bilingual and monolingual children from the age of 8 months to 30 months revealed that the bilingual children had comprehension vocabularies in each language comparable to that of monolinguals. Hoff-Ginsberg (1997) therefore argued that bilingual development might cause some delay in the development of each language but not so much as to cause these children to be outside the normal range of variation in the rate of language development.

Bishop (1997) has extensively discussed abnormal monolingual language development, in particular children with specific language impairment (SLI). In brief, SLI is defined as a disorder in the development of language despite adequate educational opportunities and normal intelligence. It requires a significant discrepancy between the child's verbal and nonverbal abilities in the absence of any additional disorders (e.g., mental retardation or autism) (e.g., Bishop, 2001; Williams, Stott, Goodyer, & Sahakian, 2000; Botting & Conti-Ramsden, 2003). Most children with SLI are poor at acquiring new vocabulary, which is reflected in their performance on tests for receptive vocabulary. For example, research on incidental learning of word meanings revealed that children with SLI understood fewer new words than age-matched normal controls after a few brief exposures to the new words in the naturalistic context of a television program (Oetting, Rice & Swank, 1995). Gleitman (1994) postulated the following process for the acquisition of new vocabulary in children: (1) the acquisition of knowledge of the concepts that words express, (2) the extraction of phonological patterns from incoming speech, and (3) the mapping of (1) and (2), that is, mapping each concept to a phonological pattern. Conceivably, poor word learning in children with SLI may be linked with a deficit at one of these processing stages. Bishop (1997) argued that deficient vocabulary learning in children with SLI is not attributable to abnormal conceptual development or lack of symbolic representation. Rather, it is attributable to poor phonological perception and memory in these children. This is because vocabulary acquisition depends on the setting up of long-term phonological representations in the lexicons, and phonological representations in these children's lexicon may be under-specified.

More recently, research into LI (language impairment) or SLI in bilingual children started to emerge, although the numbers are still few. Hakasson et al. (2003) revealed for example that Swedish-Arabic children with LI developed both languages "in the same implicational way" (Salmeh et al., 2004, p.66) as those bilingual children without LI, but showed slower development in both languages. Salmeh et al. (2004) in their longitudinal study followed the grammatical development of Swedish-Arabic bilingual children with LI and normal children (aged between four and seven) for 12 months. Their results also confirmed that their children both with and without LI developed grammatical structures in both languages in the same implicational way. However it was found that the children with LI seemed to be more vulnerable to language exposure. They were more affected by lack of the language exposure than the bilingual children without LI. Moreover, Paradis, Crago, and Rice (2003) compared French-English bilingual SLI children (mean age =

6;11) with age-matched monolingual French and English SLI children, and found that these bilingual and monolingual children both showed a difficulty in processing grammatical morphology to the same extent. Paradis et al. therefore concluded that “their dual language knowledge was not causing them to have different patterns in this domain of morphosyntax than monolinguals”, (Paradis et al., 2003; p. 123).

Further, Bishop (1997) also discussed etiological factors in SLI (albeit in monolinguals), including the language environment, genetics and neurobiology. She argued that genetic factors have been strongly implicated in the etiology of SLI. For example, the concordance of SLI among monozygotic twins is said to be almost 100% (Bishop et al., 1995). Similarly, Plante (1991) argued that developmental language disorders such as SLI are biologically transmittable, as her study revealed family aggregations of SLI.

Ors, Ryding, Lindgren, Gustafsson, Blennow and Rosen (2005) considered identifying neurobiological features for SLI as one of the main lines of SLI research and cited studies of morphometric analyses of MRI (magnetic resonance imaging) (e.g., Plante, 1991; Plante et al., 1991) or studies using functional imaging techniques such as SPECT (single photon emission computed tomography) and PET (positron emission tomography) (e.g., Saper et al., 2000). For example, Plante, et al.’s (1991) morphometric study with MRI revealed an atypical perisylvian asymmetry in SLI children – the asymmetry was seen by an atypically larger right perisylvian area compared to normal controls, while the left perisylvian area was of the same size as that of the normal controls. Plante (1991) further stated that for the majority of normal controls the asymmetry was seen with the left perisylvian area it being greater than that of the right. Plante et al. thus argued that the atypical perisylvian asymmetry in the SLI children might be due to the brain's "overproliferation of neurons that migrate out to the cerebral surface" during its development, and a possible "failure of regressive events which occur late relative to the prenatal developmental course of the affected region" (Plante et al., 1991; p.63).

In SPECT/PET studies, it has been shown that there is a linear relationship between local changes in the cerebral blood flow and glucose consumption, thus indicating local neuronal activity (Saper et al., 2000). Ors et al. therefore argued that there are morphological and functional differences in children with SLI compared to children without SLI.

Ors et al. (2005) using SPECT compared the regional cerebral blood flow (rCBF) of children with SLI and children with attention deficit hyperactivity disorder (ADHD), and found that the SLI children had symmetrical rCBF values in the left and right temporal areas whereas the ADHD children showed a typical asymmetry with the left temporal region predominant. Further, SLI children showed lower rCBF values in the right parietal as well as the subcortical regions, while the ADHD children showed symmetrical rCBF values in these areas. Both ADHD and SLI children, however, revealed lower rCBF values in the right frontal area compared to the left frontal area.

Researchers in Japan have also investigated these neurobiological abnormalities in Japanese SLI children using SPECT (e.g., Uno et al., 1997; 1999, Haruhara et al., 1999), and have reported abnormalities in the rCBF in the left temporo-parietal regions, that is, the rCBF values in the left temporo-parietal regions were significantly reduced compared to those of the right.

Moreover, Jodzio, Gasecki, Drumm, Lass and Nyka (2003) asserted that rCBF SPECT has a significant contribution to neurolinguistic research, although their patients were all neurological patients with left-hemisphere cerebral vascular accidents (CVAs).

They revealed a significant correlation between the language processing abilities (measured by BDA - Boston Diagnostic Aphasia Examination) of 50 neurological patients with left-hemisphere CVAs with a wide range of pathologies, and rCBF SPECT imaging. In particular it was found that the most prominent deficits in Wernicke's aphasia were found in the left temporal and parietal areas. Wernicke's aphasia is characterized as a receptive language aphasia with comprehension deficit.

In the present study, we report on a case study of a Japanese-English bilingual adolescent girl residing in the UK, whose behavioral data in both Japanese and English suggested that she might have SLI. Her brain SPECT also indicated that the etiology of her SLI might be due to neurobiological functional deficit rather than language environment. Parental consent for publication of the case notes/data was obtained.

CASE REPORT

The patient, EM was 14 years old at the time of assessment. She was born in the UK as the only child of Japanese parents who own a business in the UK. She was initially left-handed[(1)], as was her father, but is now more right-handed. Her handedness changed from left to right when her puberty set in. She now uses her right hand for scissors, chopsticks, and pencils and is ambidextrous for throwing balls, threading needles and using knives (personal communication with EM's mother). Her early developmental history was normal, and she was a healthy child. She had no problems with hearing.

Her first language was Japanese, which is spoken at home, and she started to learn English at the age of 4 when she started attending a private English nursery school. She subsequently attended a private English primary school and a Japanese Saturday school in order to maintain proficiency in Japanese. English became dominant once she started her education in English schools. She is now a weekly boarder at a private boarding school in the UK. She goes to Japan during school holidays (at least once a year) to see her grandparents and cousins, and converses with them in Japanese.

At the age of 8/9 years EM's mother first became aware that EM was struggling with reading and writing in English as well as in Japanese (although she had much less opportunity to read and write in Japanese). Her mother initially suspected that EM might be dyslexic, and consulted EM’s school counselor. The counselor maintained that her problems were related to EM's bilingualism, and that they would resolve in time, especially if she were encouraged to use English at home. As her parents felt unable to provide an English language environment at home, they decided to send her to a private boarding school at the age of 11 years. However, the problems persisted despite the extra curricula support including an ESOL (English for Speakers of Other Languages) course, and her mother decided that EM should be assessed professionally for her English and

Japanese language development when she was a 14-year-old. At this stage her mother's main concern was whether EM might be dyslexic.

ASSESSMENTS

Due to the availability of the appropriate examiners and the types of assessment tests, the assessments in English took place in the UK on 3rd July, while the assessments in Japanese took place in Japan on 27th July within the same year.

ASSESSMENTS IN ENGLISH

An English cognitive/educational psychologist who assessed EM's English language development wrote: "…. . When she first started school, she understood English less well than Japanese. At the age of eleven, the decision was made to enroll her at an English boarding school (as a weekly boarder) so that she could be supported with her English. Here she receives English for Speakers of Other Languages (ESOL) support. She now feels happy with her general understanding of spoken English, although she sometimes has difficulty with vocabulary when she is reading. Both she and her teachers at school are aware that, in addition to poor spelling and punctuation, she lacks organization skills in her writing …".

A summary of EM’s results on the standardized ability and literacy attainment tests (Matrix Analogy Test (MAT), British Picture Vocabulary Scale (BPVS), Wide Range Achievement Test (WRAT3) – Spelling, Wide Range Achievement Test (WRAT3) – Word Reading, and WORD Reading Comprehension) is given in Table 1.

Table 1. about here

Table 1 shows that EM’s performance on the Matrix Analogy Test and reading (the stimuli from Wide Range Achievement Test 3) was average, while her performance on comprehension tests (British Picture Vocabulary Scale and WORD reading comprehension) as well as spelling (the stimuli from Wide Range Achievement Test 3) were below average. Thus these tests revealed that EM has a comprehension deficit.

Results of the Test of Adolescent and Adult Language (TOAL) including Listening Grammar, Speaking Vocabulary, Reading Vocabulary, Reading Grammar, Writing Vocabulary, and Writing Grammar are summarized in Table 2.

Table 2. about here

The results revealed that apart from EM's scores on Reading Vocabulary and Grammar, which were within the normal range, her performance on Listening Grammar, Speaking Vocabulary and Writing Grammar were below average, while Writing Vocabulary was low (which is expected from 3% of the population). The results from the second tests in general suggest that she has a smaller vocabulary for her age.

The results of diagnostic tests for dyslexia including the Test of Word Reading Efficiency (TOWRE) and Phonological Assessment Battery (PhAB) are summarized in Table 3.

Table 3. about here

Table 3 shows that EM's performance on phonemic decoding efficiency was average but sight word and digit span efficiencies were low average. Her performance on the phonological assessment battery (PhAB) however was within average except for Spoonerisms, which was low average. It was revealed that phonemic decoding skills, which are often used as diagnostic tools for dyslexia, appear to be normal, hence suggesting that EM is not dyslexic.

ASSESSMENTS IN JAPANESE

Briefly the Japanese orthography consists of three qualitatively different scripts – logographic Kanji characters, and syllabic Hiragana and Katakana characters as shown in Table 4. Kanji is used to transcribe nouns, root morphemes of inflected verbs, adjectives and adverbs, while Hiragana is used to transcribe grammatical morphemes (i.e., function words such as but, and, etc.), inflected parts of the verbs/adjectives/adverbs and a small number of nouns as well as low frequency/complicated Kanji characters. Katakana on the other hand is used to transcribe foreign loan words (e.g., T.V., or radio). Because of this, the frequency of occurrence of Katakana is in general lower than that of Kanji or Hiragana scripts.

Table 4 about here

Table 5 shows a summary of EM's results on the tests conducted in Japanese consisting of Wechsler Intelligence Scale for Children-III (PIQ)(1), RCPM (Raven's Colored Progressive Matrices), reading/writing single hiragana/katakana characters and hiragana/katakana words, Standardized Comprehension Test of Abstract Words (SCTAW)(2) (Haruhara and Kaneko, 2003), Rey's Auditory Verbal Learning Test (immediate recall and delayed recall), and arithmetic (addition and subtraction).

Table 5 about here

The results revealed that EM's performance on these tests was well within normal range including PIQ, except for writing Katakana characters (z = -4.30, p<.0001) as well as Katakana words (we stopped the test after presenting half the total number of the stimuli, as it was apparent that she was struggling), and SCTAW (with age matched controls) (z = -5.09, p<.0001). The former results can be explained by her lack of exposure to the Japanese orthography, and the fact that the Katakana occurs in text less frequently than Kanji or Hiragana. We therefore do not necessarily think that her poor performance on Katakana writing was abnormal. In contrast, the latter results (i.e., her performance on the SCTAW) indicated that she had a severe comprehension deficit.

EM's SPECT (Single Photon Emission Computed Tomography)

SPECT is known to be one of the most widely available functional brain imaging techniques (Ryding, 2003), and according to Jordzio, et al. (2003) SPECT imaging is instrumental in the identification of decreased blood flow, which may be functionally relevant to neuropsychological impairments.

SPECT DATA ANALYSIS

The SPECT scans were obtained using ^{99m}Tc-ECD on a SIEMENS E.CAM Gamma Camera. The CBF values were then measured from the SPECT scan data. Each single SPECT slice located 7-8 mm above the orbito-meatal line was examined for the CBF values. Standardized three-dimensional regions of interests (ROIs) were examined for the frontal, thalamic, temporal, parietal and occipital areas, as well as for the whole left and the right hemisphere. All measurements were performed by a radiology technician, who was naïve to EM’s diagnoses and her conditions, at a hospital in Japan where one of the authors works.

Fig. 1 shows EM's Regional Cerebral Blood Flows (rCBF) obtained by SPECT where 99mTc-ECD was used as radioactive tracer.

Fig.1 about here

Her brain SPECT revealed significantly lower regional cerebral blood flow in the regions of the left temporal and parietal lobes.

DISCUSSION

Table 6 below shows a summary table for the results of the tests in English and Japanese conducted on EM.

Table 6 about here

The results of the current study can be summarized as follows:

(a) EM's phonemic decoding skills, which are often used as diagnostic tools for dyslexia, were within the normal range, hence suggesting that EM is not dyslexic,

(b) EM had a language deficit, in particular a comprehension deficit, and difficulties in listening/writing grammar as well as a smaller vocabulary for her age in both English and Japanese languages compared to her same age peers, despite the additional English for Speakers of Other Languages (ESOL) support (unlike AS studied by Wydell & Butterworth (1999) who was an English-Japanese bilingual with monolingual dyslexia in English),

(c) Her language deficit was not caused by general cognitive deficits as EM's WISC, Matrix Analogies Test, and RCPM results were all well within the normal range (the latter two are often considered as easily administered IQ tests), and

(d) EM's brain SPECT revealed significantly lower regional cerebral blood flow in her left temporal and parietal areas.

These behavioral data both in the English and Japanese languages thus presented a typical SLI profile as defined by other SLI researchers (Bishop, 1997; Gleitman, 1994) rather than dyslexia or within the normal range of developmental language delay often expected for bilingual children (Hoff-Ginisberg, 1997; de Houer, 1995). Most children with SLI are poor at acquiring new vocabulary (Gleitman, 1994; Oetting et al., 1995; Bishop 1997). Although some studies on the acquisition/development of language in children suggest that there is some developmental language delay in bilingual children (Rosenblum and Pinker, 1983; Umbel et al., 1992), recent general consensus suggests otherwise (e.g., Pearson et al., 1993; Hoff-Ginsberg, 1997; Hakansson et al., 2003).

Further, as discussed earlier, Paradis et al. (2003) in their study of French-English bilingual children with SLI (aged 6:11), and Salmeh et al. (2004) in their longitudinal study of Swedish-Arabic bilingual children with SLI (from aged 4 to 10) both concluded that these children's bilingualism was not the cause of their SLI.

It is therefore reasonable to assume that EM's language deficit, in particular, comprehension deficit and difficulties in listening/writing grammar coupled with a small vocabulary might not be due to her being bilingual. Instead, we believe that EM's profile is commensurate with SLI, and also her profile is very similar to that of children with SLI depicted by other researchers (Bishop, 1997; Williams et al., 2000).

Bishop (1997) further pointed out that the average child needs only "a small amount of verbal stimulation" (p.43) for normal language development. Pinker (1984) also emphasized the robustness of language acquisition in normally developing children in the context of diverse environmental experiences. Thus, in the context of normal language development, a developmental deficit such as SLI can be identified while children are still young regardless of the language environment, be it monolingual or bilingual (Bishop, 1997; Paradis et al., 2003; Salameh et al., 2004). However, EM was already 14 years old when she was tested for her language deficit. Up until then, her deficit had always been attributed to her being bilingual.

Therefore rather than the language environment, i.e., bilingualism, genetic factors could be suggested as the etiology of EM's SLI (e.g., see Bishop et al. (1995) for their twin study). Robinson (1991) argued that SLI children often have a family history of a language disorder, and this view was echoed by Plante (1991). The only tantalizing evidence for a genetic link with EM's SLI is (as EM is an only child) that one of her male cousins is reported to be having similar language problems in Japan.

It is plausible, though the genetic mechanism is not well understood, that the timing of early neuro-developmental events such as neuronal migration might be disrupted (Lyon and Gadisseux, 1991). Other studies have suggested that SLI children have cytoarchitectonic abnormalities (Cohen et al., 1989).

Indeed EM's brain SPECT revealed significantly lower regional cerebral blood flow in her left temporal and parietal lobes, suggesting that SLI might be attributable to a neurobiological abnormality (though Ors et al., 2005 for SLI children's SPECT data showed a symmetrical rCBF in the left and right temporal regions). Uno et al.'s (1999) SPECT study reported the reduced rCBF in the left temporal area of six Japanese children with SLI. Haruhara et al. (1999) also examined the cerebral blood flow of a Japanese boy (aged 11) with semantic-pragmatic deficit syndrome[(3)] using SPECT, which also revealed a similar abnormal blood flow in the left temporal area. They argued that the dysfunction of the left temporal lobe might have caused the deficit in his language comprehension.

As revealed by Jodzio et al. (2003), the neurological patients with the left hemisphere CVAs, in particular, the patients with Wernicke's aphasia (a receptive language aphasia with comprehension deficit) revealed lower rCBF in the left temporal and parietal areas. They thus showed a significant correlation between the language processing abilities of these neurological patients and rCBF SPECT imaging. Thus the SPECT results reported by Jodzio et al. (2003), Uno et al. (1997; 1999) and Haruhara et al. (1999) were comparable to EM's SPECT results.

Finally, there is one more issue that we should discuss here, which is EM's shift in handedness from the left to the right in relation to potential influences on lateralization and language functions(4). Annett (1988) argued that left-hemisphere language dominance is expected in about 80% of healthy individuals, and that about 20% have about a 50 – 50 chance of becoming either left or right-handed, thus explaining the 6-16% incidence of left-handedness and ambidextrality in the population.

Interestingly, Siebner, Limmer, Peinemann, Drezega, Bloen, Schwaiger and Conrad

(2002) investigated the long-term consequences of switching handedness using PET and a writing task (as a motor rather than language task). They found that natural right-handers showed predominant activation in the left parietal and premotor association regions during a right-hand writing task. In contrast, converted left-handers showed more bilateral activation in the right lateral premotor, parietal, and temporal cortex.

Moreover, Hoosain (1991) asked his Chinese-English bilingual converted left-handers (undergraduate students) to participate in a hemi-field word recognition task in Chinese and English. He found that switching handedness during childhood did not seem to affect lateralization of language functions either in Chinese or English, although he suggested that other motor functions might be affected.

It is thus reasonable to assume that EM’s language function might still be lateralized to the left-hemisphere, which in turn might not be functioning normally.

It is also reasonable to assume that her functional deficit was reflected in her SPECT with reduced rCBF in the left temporal and parietal regions[(5)].

It is therefore more likely that EM’s comprehension deficits, difficulties in listening/writing grammar and below average vocabulary development in both Japanese and English, when compared to same age peers, were attributable to her SLI rather than her language environment. However we cannot discount the possibility that her bilingualism might have contributed to the clinical presentation of the data.

CONCLUSION

The present study was conducted in order to investigate the apparent delay in the development of both Japanese and the English languages in EM, a 14-year old Japanese-English bilingual female. The research questions that we addressed in the study were (a) whether the delay in the development of both languages might be due to her being dyslexic, (b) whether this might be due to some environmental factors, in particular, her bilingualism, or (c) whether this might be due to some neurobiological factors. We used both behavioral and neuroimaging (i.e., SPECT) assessments. The behavioral data in the both languages did not support the conjecture that EM might be dyslexic. The results instead indicated that EM might be SLI. The SPECT data revealed that rCBF in EM's left temporal and parietal regions was significantly lower than right equivalent areas, often seen in Japanese individuals with SLI. Thus both the behavioral and neuroimaging data suggested that EM might be SLI. As to the etiology of her SLI, it is likely to be neurobiological in origin, however we cannot discount an environmental contribution to the current clinical presentation of EM's language deficit.

Footnotes

(1) EM's VIQ in Japanese was not assessed, because EM (though she is Japanese) has been educated in English in the UK.

(2) SCTAW is a word and picture matching task, and the pictures are all picturable abstract concepts. Please see examples of pictures in the Appendix (e.g., for the target word, KYORYOKU (cooperation) there are two phonological distracters, KYOORYUU (dinosaur) and KYUSHOKU (school dinner); two semantic distracters, SHINSETSU (kindness) and AYASU (humouring a baby); and unrelated distracter, HIMONO (dried fish).

(3) A semantic-pragmatic syndrome is thought to consist of fluent speech with normal syntax/prosody and poor comprehension, which sometimes leads to an inability to hold appropriate conversation.

(4) We are grateful to one of the reviewers to point out this important issue.

(5) One of the reviewers drew our attention to the study conducted by Mechelli, Crinton, Noppeney O`Doherty, Ashburner, Frackowiak, and Price (2004) who have shown that grey-matter density in the inferior parietal cortex was greater in bilinguals than monolinguals, and that the effect was statistically significant in the left, though only a

trend was observed in the right hemisphere. They further revealed that the effect was greater for early bilinguals than later bilinguals. It was also found that the grey-matter density was positively correlated with second-language efficiency and negatively correlated with age of acquisition. Mechelli et al. thus demonstrated that the structure of the human brain can be changed by environmental factors such as the acquisition of a second language.

It should be pointed out that there is no clear direct relationship between the brain's grey-matter density and rCBF. For example, Matsuda, Kitayama, Ohnishi, Asada, Nakano, Sakamoto, Imabayashi and Katoh (2002) investigated neurological patients with Alzheimer's Disease (AD), who underwent both structural MRI and SPECT. They found that the medial temporal areas showed a faster and more extensive reduction of grey-matter volume than of rCBF, while the rCBF reduction in a more posterior part of the associative temporal cortex was more apparent than the reduction in grey-matter volume. In general, however if the grey-matter density decreases, rCBF also tends to decrease.

Given that EM was an early-bilingual, EM's grey-matter density particularly in the left temporo-parietal area should also have been increased as with Mechelli et al's study, so that rCBF in this area would also have been increased. The fact that EM's

SPECT revealed a significant rCBF reduction rather than an increase tends to suggest that EM might have a genetic predisposition to show this effect. The environment (i.e., bilingualism) must have exasperated EM's weakness and exaggerated her SLI.

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Table 1.

Standardized Ability and Literacy Attainment Tests in English

Test	Age equiv.	Standard score	
Matrix Analogies Test (MAT)		102	Average
British Picture Vocabulary Scale (BPVS)	11y10m	82	*below average*
Wide Range Achievement Test (WRAT3) Spelling	10y6m	82	*below average*
Wide Range Achievement Test (WRAT3) Word Reading	13y6m-14y6m	98	Average
WORD Reading Comprehension		81	*below average*

Note:

85-115 - average (high average: 100-115; low average: 85-100)

70-84 - below average (expected from 14% of the population)

70 - low (expected from 3% of the population)

Table 2.

English Language Tests

Test		Standard Score	
Test of Adolescent and Adult Language (TOAL):			
Listening Grammar		75	*Below Average*
Speaking Vocabulary		75	*Below Average*
Reading Vocabulary		95	Average
Reading Grammar		90	Average
Writing Vocabulary		64	*Low*
Writing Grammar		75	*Below Average*

Note:

85-115 - average (high average: 100-115; low average: 85-100)

70-84 - below average (expected from 14% of the population)

70 - low (expected from 3% of the population)

Table 3.

Diagnostic Tests for Dyslexia in English

Test	Age equiv.	Standard score	
Test of Word Reading Efficiency (TOWRE):			
Sight word efficiency	12y3m	87	average (low)
Phonemic decoding efficiency	13y9m	98	average
Digit Span Memory Test		88	average (low)
Phonological Assessment Battery (PhAB):			
Naming Speed - pictures		97	average
Naming Speed - digits		102	average
Fluency - Alliteration		94	average
Fluency - Rhyme		98	average
Fluency - semantic		103	average
Spoonerisms		87	average (low)

Note:

85-115 - average (high average: 100-115; low average: 85-100)

70-84 - below average (expected from 14% of the population)

70 - low (expected from 3% of the population)

TOWRE consists of Sight Word Efficiency, Phonemic Decoding Efficiency, and a digit span memory test.

PhAB comprises picture-naming speed, digit-naming speed, fluency in alliteration and rhyme, semantic fluency, and Spoonerisms.

Table 4

Characteristics of the Japanese Orthography – Kanji, Hiragana and Katakana

Script	Word	WD-Class	Pronunciation	English
Kanji	花束	Noun	hana-taba	bouquet
Hiragana	りんご	Noun	ri-nn-go	apple
Hiragana	しかし	Function word	shi-ka-shi	but
Kanji+Hiragana	美しい	Adjective	utsuku-shi-i	beautiful
Kanji+Hiragana	忙しく	Adverb	isoga-shi-ku	busily
Katakana	テレビ	Noun	te-re-bi	T.V.

Table 5.

ME's Performance on IQ-Score, Raven's Coloured Progressive Matrices, Reading/Writing, Standardized Comprehension Test for Abstract Words (SCTAW), Rey's Auditory Verbal Learning Test, and Arithmetic in Japanese

TESTS	Score Control (s.d.)	Score EM	Accra. (%)	
WISC-III PIQ (age matched)		97		*low average*
RCPM (age matched)	33/36 (3.8)	33	91.70	normal
Reading Single Hiragana Character	19.95/20 (0.21)	20	100	normal
Writing Single Hiragana Character	19.84/20 (0.51)	20	100	normal
Reading Single Katakana Character	19.98/20 (0.15)	19	95	normal
Writing Single Katakana Character	19.90/20 (2.07)	11	55	*below -2 s.d.*
Reading Hiragana Words	19.95/20 (2.6)	20	100	normal
Writing Hiragana Words	19.70/20 (1.9)	20	100	normal
Reading Katakana Words	19.90/20 (0.2)	20	100	normal
Writing Katakana Words	19.40/20 (2.2)	7 /10	40	*below -2 s.d.*
SCTAW (age matched)	28.3/32 (3.2)	12	37.5	*below -2 s.d.*
Rey's Auditory Verbal Learning Test				
Immediate Recall	13.0 (2.6) words	13 words	86.7	normal
Delayed Recall (30 min.)	11.2 (1.9) words	11 words	73.3	normal
Addition	4.9 (4.8)	5/5	100	normal
Subtraction	4.8 (0.6)	5/5	100	normal

Note:

Control mean data are from the 6th Grade (11 – 12 yrs) of the Japanese primary school children (n=240).

RCPM : Raven's Coloured Progressive Matrices

SCTAW : Standardized Comprehension Test of Abstract Words

Table 6

A Summary Table for the Results of the Assessment Tests in English and Japanese

English		Japanese	
GENERAL INTELLIGENCE			
(MAT)	Average	WISC-III PIQ	Average (low)
		RCPM	Normal
LANGUAGE DEVELOPMENT			
British Picture Vocabulary Scale (BPVS)	***Below Average***	Abstract Word Comprehension (SCTAW)	***Below -2 s.d .***
SPEAKING & LISTENING			
(TOAL)	***Below Average***		
(TOAL)	***Below Average***		
READING & SPELLING/WRITING ATTAINMENT			
Spelling (WRAT3)	***Below Average***	Reading Single Hiragana Character	Normal
Word Reading (WRAT3)	Average	Writing Single Hiragana Character	Normal
WORD Reading Comprehension	***Below Average***	Reading Single Katakana Character	Normal
Reading Vocabulary (TOAL)	Average	Writing Single Katakana Character	***B elow -2 s.d.***
Reading Grammar (TOAL)	Average	Reading Hiragana Words	Normal
Writing Vocabulary	*Low*	Words	Normal
Writing Grammar (TOAL)	***Below Average***	Reading Katakana Words	Normal
		Words	***B elow -2 s.d.***
PHONOLOGICAL PROCESSING ABILITY & WORD READING FLUENCY			
Sight word efficiency	Average (low)		
Phonemic decoding	Average		
Naming Speed - pictures	Average		
Naming Speed - digits	Average		
Fluency - Alliteration	Average		
Fluency - Rhyme (PhAB)	Average		
Fluency - semantic	Average		
Spoonerisms (PhAB)	Average (low)		
DIGIT SPAN & RECALL			
Digit Span Memory Test (TOWRE)	Average (low)	Digit Span Memory Test (WISC-III)	Normal
		(RAVLT)	Normal
		Delayed Recall (30 min.) (RAVLT)	Normal
CALCULATION			
		Addition	Normal
		Subtraction	Normal

TOAL : Test of Adolescent and Adult Language / **TOWRE** : Test of Word Reading Efficiency

PhAB : Phonological Assessment Battery / **WRAT3** : Wide Range Achievement Test

SCTAW : Standardized Comprehension Test of Abstract Words / **RAVLT** : Rey's Auditory Verbal Learning Test

Figure Legend 1

Fig.1. EM’s Brain SPECT (Single Photon Emission Computed Tomography)

(R=right side; L=left side)

Horizontal section: (a), (b) and (c); Coronal section: (d), (e) and (f).

A significant reduction in the regional cerebral blood flow (indicated by an arrow) can be seen in the left temporal lobe (a, b, d, & e) as well as in the left parietal lobe (c, d, e, & f) compared to the same regions in the right hemisphere.

Figure Legend 2

APPENDIX

Examples of Pictures from SCTAW