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.

identification of decreased blood flow, which may be functionally relevant to neuropsychological impairments.

7. 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 rCBFs obtained by SPECT where ^{99m}Tc-ECD was used as radioactive tracer.

Her brain SPECT revealed significantly lower rCBF in the regions of the left temporal and parietal lobes.

8. Discussion

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

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 ESOL support (unlike AS studied by Wydell and 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, MAT, 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 rCBF 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-Ginsberg, 1997; De Houwer, 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),

Table 5 – ME's performance on IQ-score, RCPM, reading/writing, SCTAW, RAVLT, 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 (.21)	20	100	Normal
Writing single Hiragana character	19.84/20 (.51)	20	100	Normal
Reading single Katakana character	19.98/20 (.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 (.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.
RAVLT				
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 (.6)	5/5	100	Normal

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.

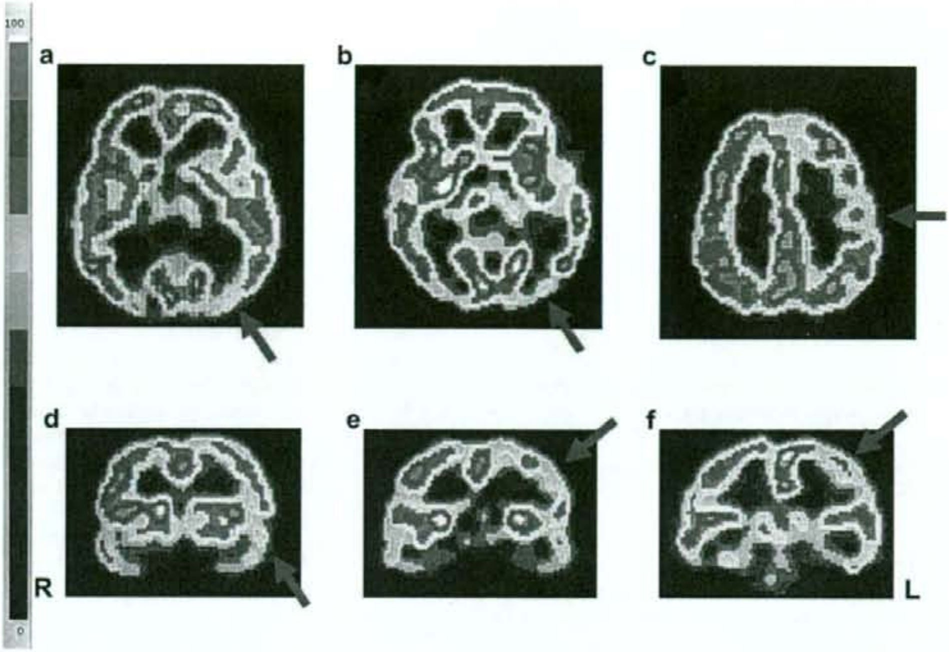

Fig. 1 – EM's brain SPECT (R = right side; L = left side). Horizontal section: (a), (b) and (c); Coronal section: (d), (e) and (f). A significant reduction in the regional cerebral blood flow (rCBF) (indicated by an arrow) can be seen in the left temporal lobe (a, b, d, & e) as well as in the left parietal lobe (c, d, e, & f) compared to the same regions in the right hemisphere.

Appendix – Examples of pictures from SCTAW.

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			
BPVS	Below average	Abstract Word Comprehension (SCTAW)	Below −2 s.d.
Speaking and listening			
Speaking Vocabulary (TOAL)	Below average		
Listening Grammar (TOAL)	Below average		
Reading and 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	Below −2 s.d.
Reading Grammar (TOAL)	Average	Reading Hiragana Words	Normal
Writing Vocabulary (TOAL)	Low	Writing Hiragana Words	Normal
Writing Grammar (TOAL)	Below average	Reading Katakana Words	Normal
		Writing Katakana Words	Below −2 s.d.
Phonological processing ability and word reading fluency			
Sight word efficiency (TOWRE)	Average (low)		
Phonemic decoding efficiency (TOWRE)	Average		
Naming Speed – pictures (PhAB)	Average		
Naming Speed – digits (PhAB)	Average		
Fluency – alliteration (PhAB)	Average		
Fluency – rhyme (PhAB)	Average		
Fluency – semantic (PhAB)	Average		
Spoonerisms (PhAB)	Average (low)		
Digit span and recall			
Digit span memory test (TOWRE)	Average (low)	Digit span memory test (WISC-III)	Normal
		Immediate recall (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.

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 Salameh 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, p. 43) further pointed out that the average child needs only "a small amount of verbal stimulation" 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 rCBF 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 CBF of a Japanese boy (aged 11) with semantic–pragmatic deficit syndrome[4] 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.[5] Annett (1996) 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 et al. (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.[6]

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.

9. 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 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

[4] 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.

[5] We are grateful to one of the reviewers to point out this important issue.

[6] One of the reviewers drew our attention to the study conducted by Mechelli et al. (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 et al. (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 rCBFs 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.

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.

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