Individual Differences Between Two Japanese Returnees - Attriters of English: A Six-Year Longitudinal Neuro-Psycholinguistic Study to Verify the CDST

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Abstract

This study addresses the need in the language attrition field for (1) employing a multiple longitudinal case study design to explore the complex and dynamic nature of language development (de Bot et al., 2007; Green, 2013; Larsen-Freeman, 2017), particularly among bilinguals who show greater individual differences than monolinguals (Bice and Kroll, 2021), and (2) employing a neurolinguistic approach in addition to a conventional psycholinguistic approach. Considering these two points, the present study examines individual differences by looking at the attritional stages of Japanese returnees losing their English in Japan and explores how brain activation undergoes change in the inferior frontal gyrus (IFG). Two Grade 7 (12-year-old) Japanese students were tracked for six years with annual data collection involving spontaneous oral/writing and brain activation data in the inferior frontal gyrus (Broca's area). The results revealed huge individual differences but little attrition, lending support to the Complex Dynamic Systems Theory and the Critical Threshold Hypothesis, respectively.

Keywords : attrition, individual differences, emergentism, CDST, brain activation, fNIRS

1. Introduction

The issue of viewing language acquisition as static versus dynamic has been heatedly debated over the years. The conventional nativists view language learning as a rule-based form of deduction controlled by a language-dedicated module (Cook, 1999). Researchers who base their theoretical framework on Universal Grammar mostly use grammaticality judgement tasks to tap into people's language competence (White, 2003). This stance obviously considers language as a static entity whereas a more dynamic view is put forward by emergentists who claim that language learning is a usage-based induction, emerging across a number of different brain modules (Mitchell *et al*., 2019; Ortega, 2009). These researchers tend to collect on-line production data (e.g., Wulff and Ellis, 2018). One of the more promising emergentism theories is the Complex Dynamic Systems Theory

(CDST, henceforth) - a combined label of the Complexity Theory (Larsen-Freeman, 2017) and the Dynamic Systems Theory (de Bot, Lowie, and Verspoor, 2007). The CDST posits that language progression and regression is adaptive, chaotic, complex, dynamic, non-linear, and variable in nature (Mitchell *et al*., 2019). Dornyei (2014) emphasizes the inclusion of a time scope because each variable changes over time, impacting one another and resulting in an endless chain reaction. The CDST has not yet been fully scrutinized to date except for a handful studies such as Chan, Verspoor, and Vahtrick (2015) and Dornyei (2014). Linck and Kroll (2019) argue, however, that the CDST is promising in the bilingual discipline because bilingual language acquisition and attrition occurs constantly in the adaption to changing demands imposed by the various linguistic environments surrounding bilinguals.

Our preliminary study on English acquisition as a second language (Taura, 2022) shows linguistic fluctuations with complexity improving linearly while accuracy and fluency drop before picking up again. This study longitudinally tracked a Japanese learner of English for 3.5 years after she had moved to Australia. Pinker's study (1995) shows a similar accuracy fluctuation in past irregular verb forms over the first four years of English acquisition as an L1. Intra-/inter-personal fluctuations were reported among four Chinese learners of English as an L2 by Larsen-Freeman (2017). Examining the attrition process, studies testing the theory are very limited except for Rossi *et al*. (2019) and Schmid (2011a), and target alphabetical rather than logographic languages.

Thus, this study attempts to verify whether the CDST is relevant using attrition data. In so doing, data have been collected both linguistically and neuro-linguistically from bilinguals of both logographic and alphabetical languages.

Research question: *Sharing almost an identical language background, do two Japanese-English bilingual returnees exhibit similar linguistic and neuro-linguistic decline in English once they are back in Japan?*

2. Method

2.1 Participants

Two Japanese returnees (A & B) participated in this research. As shown in Table 1, A moved to Canada with her family when she was 5 months old, where she stayed until she turned 11;09 for 11.04 years. B was born and grew up in the USA until she left for Japan at 12;08. Both A and B have parents with Japanese as their mother tongue, but both returnees attended local schools where the educational medium language was English when they were outside Japan.

Table 1. Participants' demographic data & yearly data collection

	OA*	LOR**	AOR***	#1	#2	#3	#4	#5	#6
A	0;05	11.04 years in Canada	11;09	12;06	13;06	14;03	15;06	16;07	17;11
B	0;00	12.08 years in USA	12;08	13;04	14;04	15;01	16;04	17;05	18;09
			INC****	0.08/9	1.08/9	2.05/6	3.08/9	4.09/10	6.01/2

*onset age, **length of residence, ***age of arrival in Japan, ****incubation

The data collection started in the very first year when they came back to Japan and enrolled in the same junior high school when A was 12;06 (the incubation period - the time elapsed since their return to Japan - being 8 months) while B was 13;04 (incubation period, 9 months), and data collection continued until they graduated from the school – 6 times altogether.

2.2 Procedures

Linguistic and neuro-linguistic data were collected yearly from both participants individually. To tap into the participants' linguistic processing, spontaneous oral and written data were collected. As a prompt to collect oral data, the wordless picture book "Frog, where are you?" (Mayer, 1969) was used (Figure 1). The participants were first instructed to go over the book to familiarize themselves with the plot before they were asked to orally narrate the book in English without any time limit. Audio data were gathered while the participants were engaging in this task, and the data were transcribed and analyzed for lexical levels, accuracy, and fluency. For spontaneous written data, *the Test of Written Language-3* (TOWL-3, henceforth) devised by Hammill & Larsen (1996) was used (Figure 2). The participants were given 15 minutes to write an English story about the picture. The written data were assessed using the scoring criteria provided by the test in terms of contextual conventions (basic English writing rules), contextual language (lexical and morphosyntactic accuracy), and story construction (impact on readers). The sum of the raw scores was converted age-appropriately to make intra-personal comparison possible across different time lines.

Figure 1. Frog, where are you?

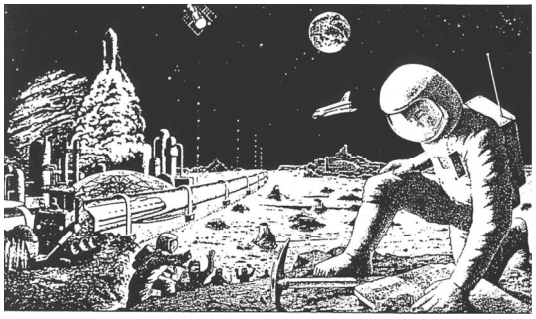

Figure 2. TOWL-3

To collect the brain activation data, a verbal fluency task (VFT) was employed (Figure 3), using a blocked design. The participants were provided with a resting task of reading aloud 'a, b, c,

d, e' repeatedly for 15 seconds. This was followed by an English letter task 'A' for instance for 15 seconds where they were told to orally produce as many words as possible starting with the letter 'A' such as April, apples, or acorns. Then followed the next English category task, a Japanese letter task, and finally a Japanese category task in the same fashion. While the participants were engaging in the VFT, brain activation data were collected using a 42-channelled Shimadzu 3000 fNIRS (functional Near-Infrared Spectroscopy) machine (Figure 4). Out of the 42 channels, special focus was placed on the left inferior frontal gyrus (IFG, BA 44 and 45) since this area is identified as relevant to generating verbal words (Abutalebi and Green, 2008). The Oxygenated Hemoglobin (Oxy-Hb) is used to represent the fNIRS data (Oxy-Hb, Dexoy-Hb, and Total-Hb) in this study (Fukuda, 2009). Prior to the data collection, both the participants and their parents signed a written consent form and they were given a book voucher for their yearly participation.

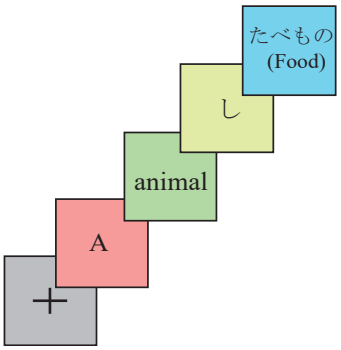

Figure 3. VFT

Figure 4. 42 channels & IFG (#33)

3. Results

The results first presented are from the linguistic data – spontaneous oral and written data, and this is followed by the VFT brain activation data.

3.1 Linguistic data

3.1.1 Language self-evaluation

A self-evaluation of their L1 (Japanese) and L2 (English) four skills (reading, writing, listening, and speaking) was collected yearly and the language they perceived as the dominant one is summarized in Table 2.

Table 2. Self-evaluation

	A	B
#1	English	English
#2	English	English
#3	Japanese ≧ English	English
#4	English	English
#5	Japanese	English
#6	Japanese	English

Across all six sessions B always maintained that English was her dominant language whereas A's dominant language gradually but not linearly alternated from English to Japanese, possibly implying that A's Japanese proficiency caught up in her 2.5 years back in Japan.

3.1.2 Spontaneous oral and written data

Oral and written transcription excerpts taken at the first (#1: the first year back in Japan) and last (#6: the sixth year) data collection times are shown below.

(A) oral #1 One day, John caught a little frog. But while he was sleeping, the frog ran away from the jar he put him in at night. When he realized the frog was gone, he started .....

(A) written #1 John was an astronot. He went out to space a lot to see what there was. He knew there was so much more stuff out there that people has yet not discovered, so he kept looking for interesting stuff .....

(A) oral #6 Little boy John caught a frog today and decided to keep him in his home. He admired it during the night then he soon became sleepy and went to bed .....

(A) written #6 A long long time ago, before the words, racism nor sexism, or any other "isms" ever existed, all human beings had only one thing in thier minds .....

(B) oral #1 Once there was a boy and a dog who found a frog near a lake. The boy and the dog were very tired, so they went to sleep. While they were sleeping, the frog ran away. In the morning .....

(B) written #1 It has been a few years from now. The future right now is not very bright. In 2012 a big Earthquake happened that literrally damaged the earth. Evrybody who survived 2012 .....

(B) oral #6 One night, a boy, a boy's father gave the boy ahh a frog and a jar. Ahhh all night long the boy and the dog were watching the frog and admiring it ....

(B) written #6 You might look at this picture and think that it's historical. Something taken from a museum. It's not. Surprisingly, this is from the future. Our future .....

Lexical (#tokens), fluency (time needed to produce a token), and complexity (#words per sentence) analyses were conducted on the data and the results are summarized in Figures 5-10. As seen in these Figures, the index of complexity rate (Figure 7) alone exhibits similar trends between the two participants while the rest of the variables show individual differences in varying degrees.

The third incubation year (2.05 and 2.06 years back in Japan for A and B, respectively) seems to be when there was a strong impact on their L2 maintenance and attrition according to their self-assessment (Table 2) and some linguistic performances (Figures 5, 9, & 10). Therefore, a closer look is taken at #3 data. A came back from Canada at 11;09 and the first data were collected when she was 12;06 while her third session took place at 14;03. B came back from the USA at 12;08 and #1 data were collected at 13;04 and #3 at 15;01. Both A and B were Grade 9 students at #3 when they had been studying back in Japan for over two years.

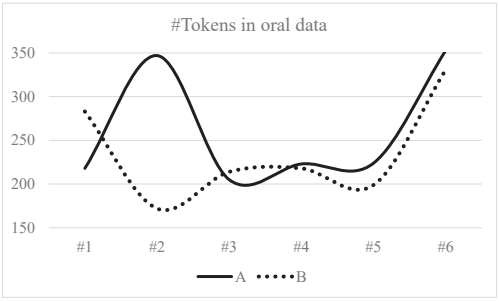

Figure 5. Lexical analysis (oral data)

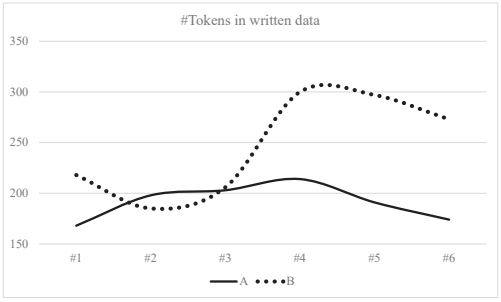

Figure 6. Lexical analysis (written data)

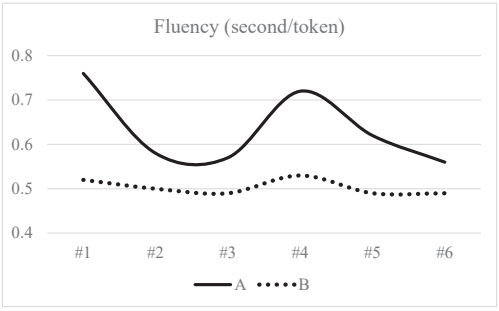

Figure 7. Fluency (oral data)

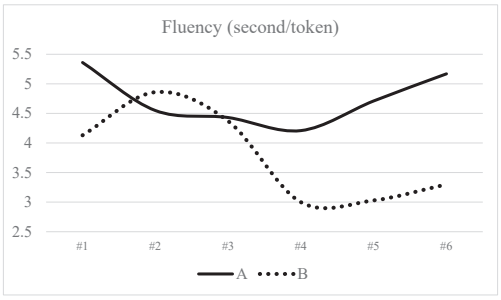

Figure 8. Fluency (written data)

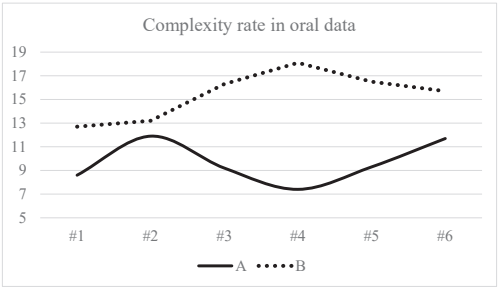

Figure 9. Complexity (oral data)

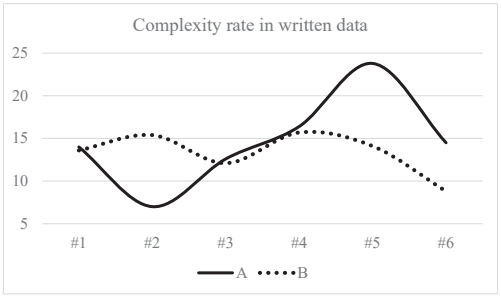

Figure 10. Complexity (written data)

First, #3 spontaneous oral data were more thoroughly examined (Table 3) and the fluency rate of the time needed to produce a token (word) was re-calculated by using the speaking time instead

of the total task time which includes a number of pauses in addition to the speaking time. Table 3 displays how A and B differ in how they narrate orally – B talked 61.3% of the time but A did so only 51.9%, which was predominantly caused by A's longer between-sentence pauses that can be attributed to issues with story and morpho-syntactic construction, not lexical retrieval as revealed in intra-sentential pauses. However, their fluency rate was identical (300.5 ms for A and 300.4 ms for B) when the total number of tokens were divided by the total speaking time at #3.

Table 3. Fluency analysis on #3 oral data

	A	B
task duration (ms)	118.63	104.85
# tokens	205	214
pause distribution		
talk (%)	51.9	61.3
intra-sentence (%)	21.4	21.0
inter-sentence (%)	26.7	17.7
average pause time (ms)		
lexical retrieval	589.37	760.52
story construction	1440.18	1682.73
time/token (ms)	*300.5*	*300.4*

Table 4. Comparison of #3 data against #2 data

		A	B
Oral narrative	complexity	↓	↑
	fluency	↓	-
	#token	↓	-
	K1/2 coverage	↓	↑
	TTR	↑	↑
	lexical density	↓	↑
Writing	complexity	↓	-
	fluency	↓	↓
	#token	-	-
	K1/2 coverage	↑	↓
	TTR	↓	↑
	lexical density	-	-
	total decrease/12	**8**	**2**
	decrease rate	**66.7%**	**16.7%**

(Upward arrows indicate improvement & downward arrows indicate deterioration while '–' shows no change.)

Secondly, spontaneous oral and written data #3 were compared to data #2 which were collected in their second year back in Japan. Table 4 shows that A suffered from linguistic attrition more severely than B as A showed a decline in 8 out of 12 elements (66.7%) such as oral/written complexity and fluency whereas B showed a decline only in 2 elements (16.6%) such as writing fluency and K1/2 coverage (K1 on the British National Corpus includes the first 1,000 words most frequently used by English native speakers).

In summary, the linguistic analyses on spontaneous data whether they are oral or written did not show any observable linear attrition in either A or B (Figures 5-10). The data taken at the third year back in Japan was rigorously scrutinized, revealing both similarities and differences between the two returnees. They were almost identical in their fluency at #3 as calculated by the time needed to orally utter a token, though in the first two years A was constantly faster at speaking English. In comparison B talked faster initially at #1 and her style was constant over the first three years (Figure 7). However, they differed in their self-assessment #3 when A said her Japanese had caught up with her English whereas B constantly assessed her English as being better than her Japanese for all six years back in Japan (Table 2). Additionally, the magnitude of fluctuation was different in their written data – B exhibited a greater fluctuation over the six years than A in the number of tokens and fluency (Figures 6 & 8), which was the opposite result in the complexity rate (Figure 10). This difference was not seen in the oral data.

3.2 Neuro-linguistic data

The fNIRS data (mMmm) collected underwent the standard procedure of converting the raw data into standardized scores and then subtracting the resting time values from the task values. Figure 11 shows the brain activation in the left IFG over the six years while A and B were carrying out the English letter task. Lower fNIRS values indicate less energy involved because tasks were more easily performed, whereas higher fNIRS values signify the participants experiencing difficulty in completing the same tasks. Right upon returning to Japan at #1, B was undertaking the task significantly more easily than A, followed by mixed results at #2, #3, and #4 before there was no significance in the results between them in the last two years of the senior high school (Figure 11 & Table 5). For intra-personal comparison across the six years, a set of ANOVAs were conducted, revealing that (1) A was activating her brain significantly more at #3 than during the other sessions ($F(5,68)=456.247$, $p<.001$, *EtaSquared*=.971) with no statistical difference among the remaining five sessions, and (2) B activated her brain significantly more at #3 ($F(5,68)=340.961$, $p<.001$, EtaSquared=.962) with statistical decrease in the order of #4, #3=#5, #6, #1).

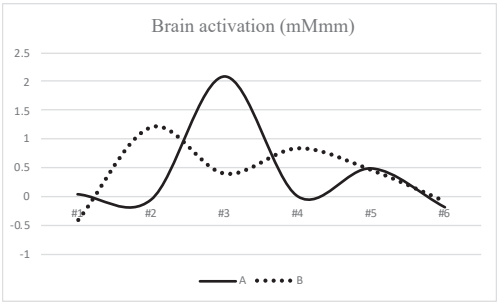

Figure 11. fNIRS data in the left IFG for the English letter task

Table 5. Paired-sample t-tests

	t tests	
#1	t(72)=6.099, p<.01	A > B
#2	t(72)=-30.449, p<.01	A < B
#3	t(72)=33.518, p<.01	A > B
#4	t(72)=-12.972, p<.01	A < B
#5	t(72)=0.244, p>.05	A = B
#6	t(72)=-1.262, p>.05	A = B

The neuro-linguistic results above resemble the linguistic data analyses seen in year #3. Another look at the fNIRS data reveals that A activated her brain significantly more at #3 (3rd year back) than #2 (2nd year back) in carrying out the English letter task while B's brain activation was significantly more at #2 than at #3 (Figures 12 & 13).

Figure 12. A's fNIRS data: #2 in the left < #3 in the right

Figure 13. B's fNIRS data: #2 in the left > #3 in the right

4. Discussion

The present study made both linguistic and neuro-linguistic attempts to investigate how two Japanese returnees underwent L2 maintenance/attrition for over six years after returning to Japan from an English-speaking milieu. Analyzing their spontaneous oral and written data along with brain activation data revealed similarities between the two participants: Neither A nor B showed any systematic or linear decline in L2 proficiency over the observed six years after they came back to Japan. This is most likely because their proficiency level was high enough prior to leaving their English-dominant communities where they had been immersed in English for most of their first twelve years of life. This interpretation seems to support the Critical Threshold Theory (Neisser, 1984) which posits a critical threshold level that guarantees resistance to loss once an item reaches that level. Another reason for their high resistance to attrition may be because of the linguistic environment at the high school where they studied for six years after returning to Japan. The school shares the same site with an international school where the educational medium language is English. The participants had many opportunities to use English in classes such as music, sports, and art with native-English speakers or during after-school club activities where students from both schools join together, coached by English-speaking teachers. Then, starting from Grade 9, the participants were able to join mainstream international school English classes for an hour every day where they continued to improve their English while in Japan. This was an ideal environment for L2 maintenance together with their high pre-attrition proficiency, leading to the participants having suffered from no severe attrition during the six years.

Now, examining the individual differences, a number of them were observed in every type of data as shown in Figures 5 to 10 and Tables 2 to 5. This was manifested the most clearly at the 3rd incubation period (#3) when (1) A self-assessed her English equal to her Japanese for the first time, (2) 66.7% of her linguistic items had deteriorated (16.7% improvement and 16.7% stabilization), and (3) significantly more brain activation was needed for English letter tasks when compared to the second incubation period (#2). In comparison, B's trend at #3 was quite contrary to this. At #3, her self-assessment still showed English dominance, only 16.6% of linguistic items had deteriorated (41.7% improvement and 41.7% stabilization), and significantly less brain activation during English VFT tasks was observed. To synthesize the data collected in their 3rd year back, A suffered from serious English attrition, which was evidently reflected in her self-assessment of L1 Japanese having caught up with her L2 English level. This, however, was not the case with B whose L2 stabilization or even improvement accounted for 85% of the linguistic items and whose performance on the L2 VFT neuro-linguistically indicated she had found the English task significantly easier.

Table 6. Comparison of B's #2 data against #1 data

#2 vs #1		B
Oral narrative	complexity	↑
	fluency	-
	#token	↓
	K1/2 coverage	-
	TTR	↑
	lexical density	-
Writing	complexity	↑
	fluency	↓
	#token	↓
	K1/2 coverage	↓
	TTR	↑
	lexical density	↑

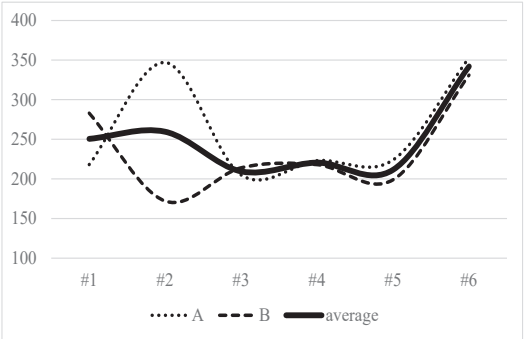

Figure 14. #tokens in oral data

Thus, A's self-evaluation, which is a subjective account on her own language performance, turned out to coincide with the brain activation levels when #3 data were compared to #2 data. This high correlation of self-evaluation with linguistic/neuro-linguistic performance was not seen in B's data at #3. A's L2 deterioration was neuro-linguistically most evident when comparing #2 to #3 (Figure 11), but such a change had already taken place with B a year earlier from #1 to #2. Her brain activation was significantly more in her second year back (#2) than in the first year (#1), which implies she needed more brain energy to complete the VFT task while spontaneous oral/written data at #2 showed improvement (41.7%), stabilization (25.0%), and deterioration (33.3%) compared to #1 data (Table 6). Regarding the relationship among these three variables (self-assessment, linguistic and neurolinguistics data), A's linguistic and neuro-linguistic data at #3 were all in accordance with her own L2 self-assessment whereas B's linguistic data at #2 were in accordance with her L2 self-assessment (English better than Japanese seen in Table 2) alone and not reflecting the brain-activation data.

Before any conclusions can be drawn in answer to the research question, the data are examined to test the validity of the CDST. The group average lines are added to the oral lexical analysis (Figure 5), written complexity rate (Figure 10), and brain activation data (Figure 11) and shown in Figures 14, 15, and 16, respectively. When the two participants underwent similar changes (as seen from #3 onwards in Figure 14, at #3 & #4 in Figure 15, and #5 & #6 in Figure 16), the group average (bold lines in Figures 14-16) appeared to be representative. However, the group average is misleading on what is precisely taking place at #1 and #2 in Figures 14, 15, and 16 as well as #2, #3, and #4 in Figure 16. This seems to imply that the group average has to be carefully examined as its usefulness may be limited.

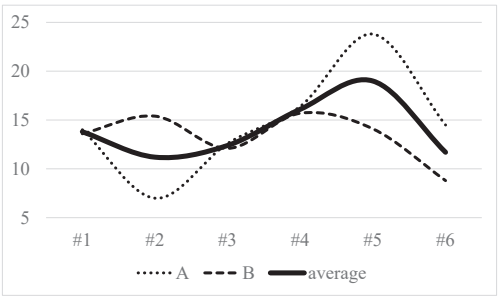

Figure 15. Written complexity

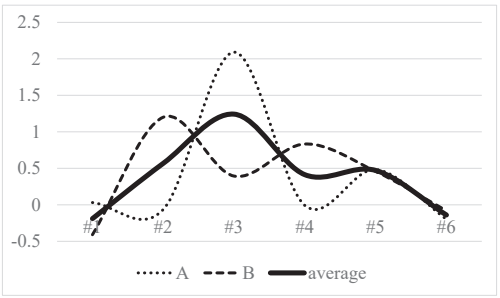

Figure 16. fNIRS data at VFT

5. Conclusion

The sole characteristic shared by the two returnees was not losing their L2 English in a linear or systematic way, or in other words they maintained their L2 proficiency. Other than this similarity, they experienced different paths during the observed six years after coming back to Japan. Intra-personal examination of A's written data disclosed there was virtually no change in the number of tokens, fluency, and complexity and in the VFT brain activation data by comparing the baseline (#1) data to the 6th incubation (#6) data (Figures 6, 8, & 10). In comparison, examining A's oral data reveals improvement in these three variables. B's oral and written data show slight improvements with some exceptions such as stabilized brain activation and a slightly lowered writing complexity rate. Self-assessment turned out to be a strong predictor variable for A when L2 suffered from linguistic and neuro-linguistic attrition in the 3rd year back. However, this was not the case with B in the 2nd year back when she underwent neuro-linguistic deterioration in L2 English, which was not in accordance with her linguistic or self-assessment. Using the group average turned out to be possibly misleading in validly interpreting the data.

Thus, synthesizing the results above enables the provision of some possible answers to the research question.

Research question: *Sharing an almost identical language background, do two Japanese-English bilingual returnees exhibit similar linguistic and neuro-linguistic decline in English once they are back in Japan?*

Firm resistance to attrition was commonly shared by the participants who are bilingual in a logographic language (Japanese) and alphabetical language (English). Other than this similarity, each participant underwent quite different fluctuations during the observed six years back in Japan, depending on what aspects of language or brain activation were examined. The results seem to lend support to the Complex Dynamic Systems Theory and the Critical Threshold Hypothesis. Through the data analysis, the importance of conducting multiple longitudinal case studies rather

than just examining cross-sectional group average was highlighted. However, this study included only two case studies and a larger number of multiple longitudinal case studies are needed for a more persuasive conclusion.

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