

TEMPORAL VARIABLES IN APHASIA AND FRENCH AS A SECOND LANGUAGE

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Abstract: This paper examines the production of temporal variables in the speech output of six learners of French as a second language and six adult Francophone aphasics. Instrumental analysis shows that the six FSL speakers produce speech output which is comparable in fluency to that of native speakers. FSL speakers do not, however, correlate pause duration with the nature of syntactic boundary. Aphasic subjects fall into two main groups, non fluent (Broca's aphasia) and fluent (Conduction aphasia). Unlike FSL subjects, both groups of aphasic patients continue to differentiate the duration of sentence-internal and sentence-final pauses.

Keywords: Temporal variables, aphasia, second language acquisition

1. INTRODUCTION

It is now well established that the study of temporal variables such as pauses and hesitation phenomena provide insight into the nature of the underlying performance strategies involved in planning and producing speech output (cf. Goldman-Eisler, 1968). In this paper we propose to compare the speech output of speakers who are in the process of acquiring French as a second language to the speech output of native speakers of French who have become aphasic following focal cerebral lesion.

As we have argued elsewhere (Schogt and Bhatt, 1990), it is not appropriate to view speech behaviour in aphasia as a mirror image of the acquisition process as proposed by Roman Jakobson (1969). Defining aphasia as a loss of language abilities resulting in a regression to an earlier stage of language performance obscures the more important question of the relationship between L1 (or L2) acquisition and L1 reacquisition.

This study compares the production of seven temporal variables in the spontaneous speech output of two groups of speakers: six learners of French as a second language and six Francophone aphasics (Broca's and Conduction aphasia).

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The variables to be analyzed are as follows (Grosjean and Deschamps, 1972, 1973; Grosjean, 1980):

(a) phonation time ratio (PTR), i.e. the percentage of speech signal duration as compared to total signal duration;
(b) speech rate (defined as the number of syllables per minute in total signal duration including pause duration);
(c) articulation rate (defined as the number of syllables per second in total signal duration excluding pause duration);
(d) average pause duration;
(e) average sentence-internal pause duration;
(f) average sentence-final pause duration;
(g) average length of runs (defined as the number of syllables produced between two pauses).

2. PREVIOUS STUDIES OF TEMPORAL VARIABLES IN SECOND LANGUAGE LEARNERS

2.1 Phonation time ratio

Previous studies have shown that values for PTR are similar both across languages and in L1 and L2. Grosjean and Deschamps (1975), for example, compared English and French language interviews and found that PTR remains stable in both languages (84.5% in French and 83.2% in English). Grosjean and Deschamps also observed, however, that pauses are organized differently according to the syntactic structure of the language. There are fewer but longer pauses in French, whereas pauses are more numerous but shorter in English.

The results presented in Raupach (1980) show that PTR also remains stable in L2 as compared to L1. PTR was virtually identical for native speakers of German (62.1%) and for a group of Francophones learning German as a second language (62%). PTR was also nearly identical for both native (55.4%) and L2 speakers of French (55.6%). PTR then appears to be a robust variable which remains similar across languages and does not differ between L1 and L2.

2.2 Speech rate

Unlike PTR, however, speech rate does seem to vary between languages and between L1 and L2. Deschamps (1980) found a difference in the values for this variable in French speakers who were learning English as a second language. Their speech rate was 153 syllables per minute in French but fell to 102 syllables per minute in English, which represents a drop of 33.33%.

Raupach (1980) reports similar results for two groups of subjects, the first, German speakers learning French and the second, French speakers learning German. Native German speakers produced 154.4 syllables per minute in German and 99.7 syllables per minute in French, a drop of 35.43%. Native French speakers produced 116.4 syllables per minute in French and 95.4 syllables per minute in German, a drop of 18.04%. Both studies thus show that for language learners speech rate is considerably lower in L2 as compared to L1.

Speech rate is also sensitive to the nature of the task. Grosjean and Deschamps (1975) show that speech rate is generally lower in description tasks (153.05 syll./min.) as opposed to interviews (264.37 syll./min.).

ISBN: 0 08 043 438X

2.3 Articulation rate

Previous research on articulation rate also indicates that this variable differs between L1 and L2. According to the results presented in Raupach (1980), native speakers of German produced 4.09 syllables per second in German and 2.98 syllables per second in French, a drop of 27.14%. Native speakers of French produced 3.69 syllables per second in French and 2.26 syllables per second in German, a drop of 38.75%. The results show that for both groups articulation rate is also lower in L2 than in L1, thus replicating the finding mentioned above for speech rate and showing that this lowering is not linked to either the duration or the number of silent pauses.

Grosjean and Deschamps (1975) also show that articulation rate, like speech rate, is sensitive to task, and is lower in description (4.45 syll./sec.) than in interviews (5.29 syll./sec.).

2.4 Average duration of silent pauses

Previous studies have shown that the duration of silent pauses is similar in L1 and L2. According to the results presented in Raupach (1980), native speakers of German produced silent pauses with an average duration of 161 centiseconds in German and 150 centiseconds in French (L2). Native French speakers produced silent pauses of 171 centiseconds in French and 110 centiseconds in German. These results thus show a slight drop in average silent pause duration in L2.

Deschamps (1980), however, found no difference in the duration of silent pauses between L1 and L2 in French speaking subjects who were learning English as a second language. The average value for sentence-internal pauses was 77 centiseconds in French (L1) and 73 centiseconds in English (L2) while the average for sentence-final pauses was 125 centiseconds in French (L1) and 120 centiseconds in English (L2).

Both these studies thus indicate that the lowering of speech rate and articulation rate in L2 noted above, cannot be attributed to an increase in the duration of silent pauses. Rather than producing longer silent pauses, L2 learners tend to increase the number of pauses. This observation has been confirmed by Raupach (1980) who found that there were a greater number of pauses in L2 than in L1.

2.5 Sentence-internal vs sentence-final pauses

Grosjean (1980) and Grosjean and Deschamps (1975) have shown that for native speakers, sentence-final pauses are both more frequent and longer than sentence-internal pauses.

As mentioned above, Deschamps (1980) has shown that French-speaking subjects learning English as a second language maintained a clear durational difference between sentence-internal and sentence-final silent pauses in both L1 and L2. When speaking French (L1), the subjects produced sentence-internal pauses with an average duration of 77 centiseconds and sentence-final pauses of 125 centiseconds. When speaking English (L2), the same subjects produced sentence-internal pauses of 73 centiseconds and sentence-final pauses of 120 centiseconds.

The results presented by Raupach (1980) confirm the observations made by Grosjean (1980) and Grosjean and Deschamps (1975) and show that for L1 the percentage of sentence-final pauses is greater than the percentage of sentence-internal pauses. In L2, however, this pattern is reversed and the percentage of sentence-internal pauses is greater than that of sentence-final pauses.

ISBN: 0 08 043 438X

2.6 Average length of runs

As mentioned above, the length of runs is measured as the number of syllables produced between two pauses. Studies by Deschamps (1980) and Raupach (1980) have shown that the average length of runs is shorter in L2 than in L1. The subjects studied in Deschamps (1980) produced 7.4 syllables in French (L1) and 4.2 syllables in English (L2), a drop of 43.24%.

The data given in Raupach (1980) shows that German-speaking subjects learning French produced runs of 10.25 syllables in German (L1) but only 5.94 syllables in French (L2), a drop of 42.05%. Similarly French-speaking subjects learning German produced runs of 7 syllables in French (L1) and only 4.63 syllables German (L2), a drop of 33.86%. Both Deschamps and Raupach attribute this lowering of the average length of runs to an increase in the frequency of sentence-internal pauses.

To summarize the above results, previous studies have shown that L2 speakers generally produce similar values to L1 speakers for PTR, average pause duration and average duration of sentence-internal and sentence-final pauses. On the other hand L2 speakers show considerably lower values for speech rate, articulation rate and average length of runs. L2 speakers can thus be generally characterized as producing less fluent speech output as compared to L1 speakers.

3. PREVIOUS STUDIES OF TEMPORAL VARIABLES IN APHASICS

3.1 Phonation time ratio

The majority of previous investigations of this topic use a phonetically imprecise definition of speech rate (see, for example, Barbizet and Lenoir, 1968; Benson, 1967; 1979; Borkowski *et al.*, 1967; Goodglass *et al.*, 1964; Goodglass and Kaplan, 1972; Kerschensteiner *et al.*, 1972; Kreindler *et al.*, 1980; Poeck *et al.*, 1972; Quinting, 1971). Speech rate is defined as the number of *words* per minute, a definition which would thus include both monosyllabic and polysyllabic words while not taking into account pause duration or articulatory rate.

More recently Deloche, *et al.* (1979) studied PTR in the speech output of five French-speaking subjects with cerebral lesion. Each subject suffered from a different language disorder: Broca's aphasia, Wernicke's aphasia, conduction aphasia, anomic aphasia and cortical dysarthria. The authors analyzed the behaviour of these subjects in a description exercise, and in spontaneous speech. The results show that aphasic subjects produce lower values for PTR than control subjects.

Bhatt (1985; 1990) examined the realization of temporal variables in the spontaneous speech of nine subjects, three with Broca's aphasia, three with Wernicke's aphasia and three with Conduction aphasia. Results show that PTR is considerably lower for subjects with Broca's aphasia (46.23) as compared to subjects with Wernicke's aphasia (75.52) or Conduction aphasia (64.64). The behaviour of these last two groups with respect to this variable is in fact comparable to that of non brain-damaged subjects as reported in Grosjean and Deschamps (1972; 1973).

3.2 Speech rate

The results for speech rate presented in Deloche *et al.* (1979) and Bhatt (1985; 1990) indicate that speech rate is considerably lower for all types of aphasic patients as compared to non brain-damaged subjects. The data given in Bhatt (1985; 1990) also show that speech rate

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in subjects with Broca's aphasia (87.5 syll./min.) is well below the speech rate of patients with Wernicke's aphasia (181.60 syll./min.) or Conduction aphasia (147.40 syll./min).

3.3 Articulation rate

Previous studies of articulation rate by Deloche *et al.* (1979) and Bhatt (1985; 1990) show that, unlike speech rate, articulation rate is remarkably similar for all types of aphasics (Broca's, 3.59 syll./sec., Wernicke's 4.19 syll./sec. and Conduction 4.14 syll./sec.). Somewhat surprisingly, values produced by aphasics for articulation rate are in fact comparable to those produced by non brain-damaged subjects. This indicates that the dysfluency that is usually associated with Broca's aphasia cannot be attributed to an actual slowing of articulation.

3.4 Average pause duration

According to Deloche *et al.* (1979) average pause duration for aphasic subjects is longer than that of non brain-damaged control subjects. The results presented in Bhatt (1985; 1990), however, indicate that average pause duration is highest for subjects with Broca's aphasia (98.64cs), followed by subjects with Conduction aphasia (70.08cs) and then by those with Wernicke's aphasia (48.20cs). All three groups of aphasic patients produce values for average pause duration that are comparable to those produced by non brain-damaged patients.

3.5 Sentence-internal vs sentence-final pauses

The data given in Bhatt (in press) show that subjects with Broca's, Wernicke's and Conduction aphasia continue to maintain a distinction between duration of sentence-internal and sentence-final pauses (Broca's, 84.78cs vs 152.66cs, Conduction, 65.18cs vs 93.63cs and Wernicke's, 44.62 vs 54.97cs). This distinction is, then best preserved among subjects with Broca's aphasia.

3.6 Average length of runs

Though calculated in a slightly different way than other studies (based on accentual groups rather than number of syllables between pauses), the results presented in Bhatt (1985) show that the average for subjects with Broca's aphasia is 1.71 syllables per accentual group, for subjects with Conduction aphasia the average is 2.09 syllables per accentual group and the value for subjects with Wernicke's aphasia is 2.79 syllables per accentual group. These values are all considerably lower than the average of 3.96 syllables per accentual group observed for nine non aphasic subjects with right hemisphere lesion.

To summarize the studies presented above, aphasic speakers generally fall into two groups with respect to the nature of speech output, fluent (Broca's aphasia, anterior lesion) and non fluent (Wernicke's aphasia and Conduction aphasia, posterior lesion). There are no major differences between aphasics and non brain-damaged subjects for articulation rate, average pause duration and average duration of sentence-internal ve sentence-final pauses. On the other hand, subjects with Broca's aphasia produce considerably lower values for speech rate than non brain-damaged subjects, whereas subjects with Wernicke's or Conduction aphasia resemble non brain-damaged subjects for this temporal variable. The two variables which appear to differentiate brain-damaged subjects from non brain-damaged subjects are speech rate and average length of runs.

ISBN: 0 08 043 438X

4. SUBJECT POPULATION AND SPEECH SAMPLE

Group A consists of six FSL learners. All six were students enrolled in a Second-Year Oral French course at the University of Toronto. There were five female subjects and one male subject. Three FSL students (subgroup A1, subjects A, B and C) were instructed to speak about natural (i.e. organically grown) foods. The other three students (subgroup A2, subjects D, E and F) were instructed to imagine that they had been bitten by a dog and that they were speaking to the dog's owner.

Group B consists of six right-handed, unilingual, French-speaking aphasic adults. All were hospitalized at either the Clinique des Maladies du Système Nerveux of the Hôpital de la Salpêtrière or at the Neurosurgical Unit of the Hôpital Ste. Anne, in Paris, France. Each patient had suffered a unilateral cerebral lesion as confirmed by the neurosurgeon's report following surgery or by Computerized Axial Tomography.

Three aphasic patients (subgroup B1, subjects G, H and I) had suffered anteriorly located cerebral lesion to the frontal area of the left hemisphere. These patients were classified as having Broca's aphasia. The other three patients (subgroup B2, subjects J, K and L) were diagnosed as having posteriorly located lesion to the parietal area of the left cerebral hemisphere. These subjects all suffered from Conduction aphasia.

The aphasic speech sample submitted to instrumental analysis was drawn from the spontaneous speech section of the clinical aphasia examination battery used at the time at the Salpêtrière and St. Anne Hospitals. Since this section occurs at the very beginning of the battery, the effect of fatigue is minimal. The patients were interviewed in a clinical setting, and were replying to questions about their illness, profession, and similar topics.

We recognize that the corpus examined here is limited both in number of subjects and size of speech sample. The results presented here thus provide a series of working hypotheses which require further empirical investigation rather than definitive, final conclusions.

5. RESULTS OF THE INSTRUMENTAL ANALYSIS OF TEMPORAL VARIABLES

5.1. Phonation Time Ratio

The data presented in Table 1 show that the two subgroups of FSL subjects produce comparable values for PTR (A1=77.25, A2=75.89). PTR represents approximately three quarters of total phonation time for both sets of FSL learners. The values produced by aphasic subjects are, however, considerably lower than those produced by the FSL subjects studied here. Values for both groups of aphasics are also lower than those reported by Grosjean and Deschamps (1972; 1973) for non brain-damaged speakers. The overall PTR average for the three subjects with Conduction aphasia (sub-group B2) is 64.64, or approximately two-thirds of total phonation time. The lowest average for PTR is produced by subjects with Broca's aphasia (i.e. subgroup B1). These subjects produce an overall average PTR of 45.56, with subjects G (39.55) and I (35.73) producing the lowest values for this temporal variable. These last two patients thus produce speech output which shows an inversion of the usual relation between duration of phonation and duration of unvoiced pauses.

Direct statistical comparison produces significant results between subjects with Broca's aphasia and the two FSL groups.

ISBN: 0 08 043 438X

	Total duration in cs	Speech duration in cs	Pause duration in cs	Phonation Time Ratio (PTR)	Percentage of silent pauses
A (FLS A[1])	6211.221	5155.497	1055.724	83.003	16.997
B (FLS A[1])	7043.786	5010.601	2033.185	71.135	28.865
C (FLS A[1])	5376.417	4173.673	1202.744	77.629	22.371
A[1] Average	6210.475	4779.924	1430.551	77.256	22.744
Standard deviation	680.701	432.746	430.333	4.852	4.852
Variability	0.110	0.091	0.301	0.063	0.213
D (FLS A[2])	6188.246	4361.796	1826.450	70.485	29.515
E (FLS A[2])	5631.255	4415.109	1216.146	78.404	21.596
F (FLS A[2])	4137.723	3259.281	878.442	78.770	21.230
A[2] Average	5319.075	4012.062	1307.013	75.886	24.114
Standard deviation	865.738	532.741	392.320	3.822	3.822
Variability	0.163	0.133	0.300	0.050	0.159
G (BRO B[1])	22553.000	8922.000	13631.000	39.560	60.440
H (BRO B[1])	15141.000	9297.500	5843.500	61.406	38.594
I (BRO B[1])	21277.000	7602.000	13675.000	35.729	64.271
B[1] Average	19657.000	8607.167	11049.833	45.565	54.435
Standard deviation	3235.505	727.104	3681.477	11.310	11.310
Variability	0.165	0.084	0.333	0.248	0.208
J (COND B[2])	9780.500	6734.500	3046.000	68.856	31.144
K (COND B[2])	13421.000	8631.500	4789.500	64.313	35.687
L (COND B[2])	12560.000	7631.500	4928.500	60.760	39.240
B[2] Average	11920.500	7665.833	4254.667	64.643	35.357
Standard deviation	1553.497	774.827	856.538	3.313	3.313
Variability	0.130	0.101	0.201	0.051	0.094
FLS A[1] vs FLS A[2]					t = 0.3842 p (4 d.f.) = 0.7204
FLS A[1] vs BRO. B[1]					t = 4.460 p (4 d.f.) = 0.0112
FLS A[1] vs COND. B[2]					t = 3.718 p (4 d.f.) = 0.0205
FLS A[2] vs BRO. B[1]					t = 4.399 p (4 d.f.) = 0.0117
FLS A[2] vs COND. B[2]					t = 3.850 p (4 d.f.) = 0.0183
BRO. B[1] vs COND. B[2]					t= -2.804 p (4 d.f.) = 0.0486

Table 1: Temporal variables and phonation time ratio

ISBN: 0 08 043 438X

5.2 Speech rate (number of syllables per minute)

Speech rate was calculated according to Goldman-Eisler's (1968) proposed method: total number of syllables divided by total sample duration (including both speech signal and pause duration). Results are given in Table 2. As stated above, the values obtained by this method are more phonetically precise than those obtained by the traditional measures of number of words per minute used by many previous researchers.

The results for speech rate mirror the results obtained for PTR. The difference between the two subgroups of FSL learners is minimal (A1=185 syll./min., A2=193 syll./min.). Once again the averages for both aphasic groups are well below the averages for non brain-damaged subjects obtained by Grosjean and Deschamps (1972; 1973) and well below the values produced by FSL learners. Subjects with Conduction aphasia (B2=147 syll./min.) do, however, produce considerably higher values for speech rate than subjects with Broca's aphasia (B1=87.88 syll./min.).

Direct statistical comparison of the averages for the four groups shows a highly significant difference between both FSL subgroups A1 and A2 and subgroup B1, subjects with Broca's aphasia. There is however only a mild difference between the subjects with Broca's aphasia and those with conduction aphasia.

5.3 Articulation rate (syllables per second)

Table 3 gives the results obtained from the analysis of articulation rate. Articulation rate was calculated according to the method proposed by Goldman-Eisler (1968) and Grosjean and Deschamps (1972; 1973).

In strong contrast to the results discussed above for PTR and speech rate, values for articulation rate (which excludes pause duration) are remarkably similar across all subject groups. There are still differences between the groups but they are considerably milder than the differences observed when pauses are included in the calculation of temporal variables. Furthermore, the values found for the FSL subjects (A1=4.276 syll./sec., A2=4.503 syll./sec.) are comparable to those reported by Grosjean and Deschamps (1975) for description and interview tasks (see section 2.3 above).

This result is surprising given that, as mentioned above, group B1 subjects (Broca's aphasia) are held to produce non-fluent speech output. It would seem, however, that the key factor in the dysfluency attributed to subjects with Broca's aphasia is not an actual slowing in articulation but rather an increase in pause duration (Bhatt 1985, 1990).

Statistical comparison of the averages of the subgroups reveals the existence of mild differences between both groups of FSL subjects and subjects with Broca's aphasia.

ISBN: 0 08 043 438X

	Speech rate (syllables per minute)
A (FLS A^1)	202.858
B (FLS A^1)	163.548
C (FLS A^1)	188.601
Average	185.002
Standard deviation	16.249
Variability	0.088
D (FLS A^2)	215.246
E (FLS A^2)	192.852
F (FLS A^2)	172.558
Average	193.552
Standard deviation	17.434
Variability	0.090
G (BRO B^1)	77.420
H (BRO B^1)	103.030
I (BRO B^1)	83.190
Average	87.880
Standard deviation	10.969
Variability	0.125
J (COND B^2)	183.430
K (COND B^2)	135.010
L (COND B^2)	124.200
Average	147.547
Standard deviation	25.754
Variability	0.175
FLS A^1 vs FLS A^2	t = -0.6214 p (4 d.f.) = 0.5680
FLS A^1 vs BRO. B^1	t = 8.581 p (4 d.f.) = 0.001
FLS A^1 vs COND. B^2	t = 2.103 p (4 d.f.) = 0.1002
FLS A^2 vs BRO. B^1	t = 8.886 p (4 d.f.) = 0.0009
FLS A^2 vs COND. B^2	t = 2.562 p (4 d.f.) = 0.0625
BRO. B^1 vs COND. B^2	t= -3.692 p (4 d.f.) = 0.0210

Table 2: Speech rate

ISBN: 0 08 043 438X

	Articulatory rate (syllabes per second)
A (FLS A¹)	4.291
B (FLS A¹)	3.890
C (FLS A¹)	4.647
Average	4.276
Standard deviation	0.309
Variability	0.072
D (FLS A²)	5.138
E (FLS A²)	4.372
F (FLS A²)	3.998
Average	4.503
Standard deviation	0.474
Variability	0.105
G (BRO B¹)	3.260
H (BRO B¹)	2.800
I (BRO B¹)	3.880
Average	3.313
Standard deviation	0.443
Variability	0.134
J (COND B²)	4.440
K (COND B²)	3.500
L (COND B²)	3.410
Average	3.783
Standard deviation	0.466
Variability	0.123
FLS A¹ vs FLS A²	t = -0.6949 p (4 d.f.) = 0.5254
FLS A¹ vs BRO. B¹	t = 3.088 p (4 d.f.) = 0.0366
FLS A¹ vs COND. B²	t = 1.527 p (4 d.f.) = 0.2014
FLS A² vs BRO. B¹	t = 3.177 p (4 d.f.) = 0.0336
FLS A² vs COND. B²	t = 1.876 p (4 d.f.) = 0.1339
BRO. B¹ vs COND. B²	t= -1.266 p (4 d.f.) = 0.2742

Table 3: Articulatory rate

ISBN: 0 08 043 438X

5.4 Average pause duration

The results in Table 4 indicate that average pause duration is, as could be expected, longer for subjects with Broca's aphasia (B1=98.636cs) than for the other three groups. There is, however, considerable variability within this subgroup. Subject H's average pause duration (58.435cs) is, for example, lower than that of all subjects with Conduction aphasia and comparable to the values produced by FSL subjects. This variability among subjects with Broca's aphasia produces a high standard deviation for this subgroup. In turn, direct statistical comparison of the values obtained for the subgroups of subjects with Broca's aphasia to other subgroups does not produce a significant result. Direct comparison of the averages of the subgroups is significant in only one case, that of FSL subjects in subgroup 2 when compared to subjects with conduction aphasia.

5.5 Average duration of sentence-internal and sentence-final pauses

Values for average duration of sentence-internal and sentence-final pauses are given in Table 5. Average internal pause duration reveals reasonably strong differences between FSL subjects and aphasic subjects. FSL subjects (A1=45.244cs, A2=52.166cs) generally produce shorter internal pauses than aphasic subjects (B1=84.77cs, B2=65.18cs). In fact, subjects in subgroup A1 produce sentence-internal pauses which are considerably shorter than those of the three other subgroups. This is the only variable where there is a significant difference between the two subgroups of FSL subjects. Statistical comparison of the values for sentence-internal pause duration produces highly significant results between subgroups A1 and A2, as well as between subgroups A1 and B2 (FSL vs Conduction aphasia). Results of the comparison between subgroups A1 and B1 (FSL vs Broca's aphasia) are still significant, as are the comparisons between groups A2 and B2 (FSL vs Conduction aphasia). The only result which does not approach statistical significance is the comparison between the two aphasic subgroups.

As for sentence-final pauses, average duration is again lower for FSL subjects than for aphasic subjects. It is important to note, however, the considerable degree of variability observed within subgroup A1 (FSL) and subgroup B1 (Broca's aphasia). Once again, this variability is in large measure responsible for the lack of statistically significant results to be found when comparing the four subgroups.

Despite this lack of statistical difference, one should note, however, that with the exception of subject B, none of the other five FSL learners correlates pause duration with nature of syntactic boundary. Sentence-internal pauses are similar in duration to sentence-final pauses. In fact, for FSL subjects A and C the average duration of sentence-final pauses is actually shorter than the average duration of sentence-internal pauses.

On the other hand, five aphasic subjects out of six produce sentence-final pauses that are longer in average duration than sentence-internal pauses. Subject H is the only aphasic patient to counteract this trend. Even more surprisingly, it is subjects G and I with Broca's aphasia who maintain the greatest contrast between the duration of sentence-internal and sentence-final pauses. As we have already seen these subjects produce non fluent speech output characterized by low PTR and low speech rate.

ISBN: 0 08 043 438X

	Average length of silent pauses (in cs)
A (FLS A^1)	45.901
B (FLS A^1)	88.399
C (FLS A^1)	46.256
Average	60.187
Standard deviation	19.950
Variability	0.331
D (FLS A^2)	58.918
E (FLS A^2)	55.279
F (FLS A^2)	51.673
Average	55.290
Standard deviation	2.958
Variability	0.053
G (BRO B^1)	139.092
H (BRO B^1)	58.435
I (BRO B^1)	98.381
Average	98.636
Standard deviation	32.929
Variability	0.334
J (COND B^2)	64.809
K (COND B^2)	76.024
L (COND B^2)	69.415
Average	70.083
Standard deviation	4.603
Variability	0.066
FLS A^1 vs FLS A^2	t = 0.4206 p (4 d.f.) = 0.6957
FLS A^1 vs BRO. B^1	t = -1.730 p (4 d.f.) = 0.1587
FLS A^1 vs COND. B^2	t = -0.8372 p (4 d.f.) = 0.4496
FLS A^2 vs BRO. B^1	t = -2.271 p (4 d.f.) = 0.0856
FLS A^2 vs COND. B^2	t = -4.683 p (4 d.f.) = 0.0094
BRO. B^1 vs COND. B^2	t= 1.487 p (4 d.f.) = 0.2111

Table 4: Average length of pauses

ISBN: 0 08 043 438X

	Average length of sentence-internal pauses (in cs)	Average length of sentence-final pauses (in cs)	Difference between internal and final pauses
A (FLS A^1)	46.357	44.527	-4.530
B (FLS A^1)	45.597	154.979	239.889
C (FLS A^1)	43.779	41.215	-5.857
Average	45.244	80.150	76.501
Standard deviation	1.082	52.96	115.534
Variability	0.024	0.660	1.510
D (FLS A^2)	52.258	62.536	19.668
E (FLS A^2)	53.696	58.671	9.265
F (FLS A^2)	50.544	53.741	6.325
Average	52.166	58.316	11.753
Standard deviation	1.288	3.599	5.724
Variability	0.025	0.062	0.487
G (BRO B^1)	111.358	199.032	78.732
H (BRO B^1)	58.690	52.125	-11.186
I (BRO B^1)	84.280	206.780	145.349
Average	84.776	152.646	70.965
Standard deviation	21.504	71.149	64.141
Variability	0.254	0.466	0.904
J (COND B^2)	55.590	86.540	55.675
K (COND B^2)	70.610	119.360	69.041
L (COND B^2)	69.340	75.000	8.163
Average	65.180	93.633	44.293
Standard deviation	6.801	18.792	26.124
Variability	0.104	0.201	0.590
FLS A^1 vs FLS A^2	t = -7.127 p(4 d.l.) = 0.002	t = 0.7129 p(4 d.l.) = 0.5153	t = 0.9695 p(4 d.l.) = 0.3872
FLS A^1 vs BRO. B^1	t = -3.180 p(4 d.l.) = 0.0335	t = -1.416 p(4 d.l.) = 0.2297	t = 0.7256 p(4 d.l.) = 0.9456
FLS A^1 vs COND. B^2	t = -5.014 p(4 d.l.) = 0.0074	t = -0.4158 p(4 d.l.) = 0.6989	t = 0.4710 p(4 d.l.) = 0.6622
FLS A^2 vs BRO. B^1	t = -2.622 p(4 d.l.) =0.0587	t = -2.293 p(4 d.l.) = 0.0835	t = -1.593 p(4 d.l.) = 0.1865
FLS A^2 vs COND. B^2	t = -3.256 p(4 d.l.) = 0.0312	t = -3.197 p(4 d.l.) = 0.0330	t = -2.107 p(4 d.l.) = 0.1028
BRO. B^1 vs COND. B^2	t = 1.505 p(4 d.l.) =0.2068	t = 1.389 p(4 d.l.) = 0.2372	t= 0.6670 p(4 d.l.) = 0.5413

Table 5: Average duration of sentence-internal and sentence-final pauses.

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5.6. Average length of runs

The strongest differences between FSL learners and aphasic subjects are to be found with respect to average length of runs (see Table 6). Values for both groups of FSL subjects are similar with subgroup A1 producing an average of 8.342 syllables between silent pauses and subgroup A2 producing an average of 7.398 syllables between pauses. Patients with Conduction aphasia produce runs that are approximately one-half the length of those produced by FSL subjects with an average of 4.017 syllables per run. Subjects with Broca's aphasia produce by far the shortest runs with an average of only 2.032 syllables between pauses.

All statistical comparisons between subgroups of FSL learners and subgroups of aphasic patients produce highly significant results. The strongest results are those observed for comparisons between the two subgroups of FSL learners and the subjects with Broca's aphasia. There is also a statistically significant difference between the two subgroups of aphasic patients. This result strongly indicates that the change that is most clearly associated with aphasia is the lowering of the average length of runs. Both types of aphasic patients produce considerably shorter lengths of uninterrupted speech than do non brain-damaged subjects, even those who are in the process of acquiring the language being produced.

6. CONCLUSION

Before stating our general conclusions let us draw a brief sketch of the temporal variable profile produced by the second language learners studied here. When compared to previous studies, the speech output of our six FSL learners is in fact similar to the speech output of native speakers of French with respect to the following six temporal variables: i) phonation time ratio; ii) speech rate; iii) articulation rate; iv) average duration of silent pauses; v) average length of sentence internal pauses and vi) average length of runs. The FSL learners examined here do not show the reduction in PTR, in speech rate and average length of runs reported by Deschamps (1980) and Raupach (1980). The FSL subjects in this study can thus be considered to constitute a fairly fluent group of speakers with respect to temporal variables.

In spite of this general overall fluency, our FSL speakers crucially differ from native Francophones with respect to the average duration of sentence-final pauses. Five out of six FSL learners did not correlate pause duration with the nature of the syntactic boundary by lengthening sentence-final pauses. Furthermore, as mentioned above, two FSL subjects produced sentence-final pauses which were in fact shorter in average duration than that of sentence-internal pauses.

Turning now to the speech output of our two subgroups of aphasic patients, we can state that the values produced for phonation time ratio are similar to those produced by non brain-damaged Francophones in description tasks but lower than the values observed for interviews. As for speech rate, subjects with Conduction aphasia produce values for this variable which are comparable to those produced by non brain-damaged subjects. On the other hand, speech rate is significantly lower for patients with Broca's aphasia. The results for articulation rate in both groups of aphasic subjects are, on the other hand remarkably stable and close to those found for non brain-damaged subjects. The values produced by aphasic patients for average pause duration are also comparable to those observed in non brain-damaged subjects. Finally the distinction between average duration of sentence-internal and sentence-final pauses is maintained by both groups of aphasic subjects in a fashion that is comparable to non brain-damaged subjects. The temporal variable that most clearly indicates the effect of cerebral lesion is then the average length of runs. Values for this temporal variable are considerably lower for both groups of aphasic patients with the most severe reduction being found for subjects with Broca's aphasia.

ISBN: 0 08 043 438X

	Average length of runs
A (FLS A¹)	8.875
B (FLS A¹)	8.391
C (FLS A¹)	7.760
Average	8.342
Standard deviation	0.457
Variability	0.055
D (FLS A²)	7.031
E (FLS A²)	8.217
F (FLS A²)	6.944
Average	7.398
Standard deviation	0.581
Variability	0.078
G (BRO B¹)	1.915
H (BRO B¹)	2.222
I (BRO B¹)	1.960
Average	2.032
Standard deviation	0.135
Variability	0.067
J (COND B²)	5.071
K (COND B²)	3.909
L (COND B²)	3.071
Average	4.017
Standard deviation	0.820
Variability	0.204
FLS A¹ vs FLS A²	t = 2.212 p (4 d.f.) = 0.914
FLS A¹ vs BRO. B¹	t = 22.94 p (4 d.f.) = 0.0000
FLS A¹ vs COND. B²	t = 7.980 p (4 d.f.) = 0.0013
FLS A² vs BRO. B¹	t = 15.58 p (4 d.f.) = 0.0001
FLS A² vs COND. B²	t = 5.827 p (4 d.f.) = 0.0043
BRO. B¹ vs COND. B²	t= -4.137 p (4 d.f.) = 0.0144

Table 6: Average length of runs

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As we have stated elsewhere (Bhatt, 1990) the non-fluent nature of the speech output of subjects with Broca's aphasia is attributable neither to an increase in the length of pauses nor to an actual slowing of the rate of articulation. The crucial change in the speech output of patients with Broca's aphasia is an important increase in the number of pauses, which in turn dramatically lowers the length of runs and confers an overall impression of discontinuity. This discontinuity of speech output does not, however, appear to be correlated with an inability to plan sentence-level units as has been suggested by some authors (Danly and Shapiro, 1982). Two out of three subjects with Broca's aphasia studied here continue to correlate pause duration and syntactic boundary by producing sentence-final pauses which are considerably longer than sentence-internal pauses. Simply put, lack of continuity of speech output does not necessarily imply lack of knowledge of the nature of the underlying grammatical constituents.

Let us now return to the comparison of FSL subjects and aphasic patients. The portrait that emerges with respect to temporal variables does not appear to support the view that these sets of speakers constitute mirror images of one another, as suggested for L1 acquisition by Roman Jakobson (1969). In fact the interpretation that suggests itself is that these two sets of subjects are in complementary distribution.

FSL subjects produce a continuous flow of speech, but do not respect the syntactic hierarchy of the units they are producing. This coincides neatly with Fathman's 1980 hypothesis that second language learners plan and execute their utterances phrase by phrase rather in sentence level units.

Aphasic subjects on the other hand, produce discontinuous speech output, but continue to respect the underlying difference in the nature of syntactic boundaries. As such these utterances maintain their overall structure despite the obvious disorder in the articulatory production of the sentences.

This in turn suggests that acquisition (of L1 or L2) and reacquisition (of L1) are not processes that can be seen as following parallel paths of evolution. Acquisition and reacquisition in fact appear as rather different language performance strategies which reflect considerable differences in the internalized knowledge of the language.

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