AURAL AUTOMATICITY AS A MEASURE OF BILINGUALISM

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ABSTRACT

Two groups of French-English bilinguals, 20 predominantly English-speaking and 20 predominantly French-speaking, were placed before a specially-designed apparatus containing 10 coloured keys, five for the left hand and five for the right. In response to two-word (e.g. *left red*) and full sentence (e.g. Press the *red* button on the *left*) instructions, *S*s were asked to depress the appropriate key as quickly as possible. The latency of the response, i.e. time between the offset of the instruction and the depressing of the appropriate key, was measured and analyzed in two 2 x 2 x 2 analyses of variance. The findings indicated that predominantly English-speaking *S*s reacted more quickly to English than to French instructions but did not commit more errors in French than in English. Similarly, predominantly French-speaking subjects showed the same degree of accuracy of response, but reacted faster in French than in English. Differences in reaction time to the two-word and full sentence instruction are considered to be due to differences in the position of the key words (i.e. direction and colour) in English and French sentence structures. The results suggest that latency of bilinguals' reaction to aurally-presented stimuli in the two languages may prove to be a useful index of bilingualism.

The degree of bilingualism in a speaker has been measured by various means, some "direct" and others "indirect" (Macnamara, 1967a). One indirect measure which has been shown to correlate highly with a general degree of bilingualism over a wide range of linguistic skills is verbal fluency or 'automaticity' (Dunkel, 1948; Warshaw, 1953), the chief characteristic of which is speed of response, a commonly accepted index of habit strength. Tests in this area of measurement have focused on the speed of responding to aural stimuli in two languages (Rao, 1964; Scherer and Wertheimer, 1964), on speed of verbal production in two languages (Ervin, 1961; Lambert, Havelka and Gardner, 1959; Lambert and Moore, 1967; Johnson, 1953; Macnamara, 1967), and latency of response to a visual signal (Lambert, 1955). In all of these studies, the bilingual measures obtained were found to be correlated with either language background or estimates of years of experience in both languages.

In his study of speed of response to visual stimuli the *S*s used in the Lambert (1955) study were required to manipulate eight finger-keys, the stems of which were differently coloured, in response to directions to depress a particular key. These directions were presented visually in either French or English. *S*s' comparative speed of response to 32 directions in both languages was determined. Lambert (1959) found that the differences in reaction time to the two sets of instructions was related to the language history of his *S*s. In addition, it correlated significantly with a measure of *S*s' comparative associational fluency in the two languages ($r = +0.82$).

The present study was designed to study aural automaticity of French-English bilinguals in relation to their level of linguistic experience.

1.0 METHOD

1.1 SUBJECT (*S*s)

Forty male students from the University of Western Ontario served as *S*s. Group E consisted of 20 English-speaking students who had received their university training in English, but were majoring in French. Group F consisted of 20 students who were natives of Quebec or France and who had received their university training in French or in an English-French bilingual setting. Thus, the *S*s were selected on the basis of their differential facility with English and French. The dominance, either English or French, was determined with the aid of personnel in the French Department at the University.

1.2 APPARATUS

*S*s were placed before a keyboard containing 10 coloured keys, 5 for each hand. Only the colours green, blue, red, white and yellow were used, but the colour arrangement was different for the two hands.

A Schmitt trigger[1] was connected to a speaker output of a stereo taperecorder through an impedance matching transformer. The A.C. input was half-wave rectified and filtered by capacitor to produce the D.C. voltage required to operate the Schmitt trigger. The presentation of the stimulus directions, which were taperecorded, thus caused a D.C. voltage to be applied to the Schmitt trigger. A zener diode in the input circuit made the Schmitt trigger insensitive to variations in voltage higher than the trigger voltage. The offset of the trigger at the end of the stimulus instructions caused a timeclock to start. The pressing of any one of the ten finger keys operated an interlocking relay system which stopped the timeclock, and rendered all the remaining finger keys electrically inoperative. The number of the finger key which the *S* pressed was indicated to *E* on a rear screen projector readout unit. The same number was also recorded in binary fashion on a four pen event recorder. The trial number was indicated by a counter when the 'reset' button was pressed. Panel lights and voltage indicator allowed *E* to monitor the operation of the Schmitt trigger.

1.3 PROCEDURE

*S*s were instructed to place their fingers on the finger keys as though they were operating a typewriter. They were told to listen carefully to the tape instructions, and to depress the proper finger key as quickly as possible. Two sets of instructions were prepared—two word (e.g. left red) and complete sentence (e.g. Press the red button on the left). For each set, similar pairs of instructions were prepared in both English and French

[1]The equipment used in this study was constructed by Dr. J. T. Hawkins, Research Psychologist, London Psychiatric Hospital, London, Canada.

and instructions in the two languages were randomly ordered. After 16 practice trials, *S*s were presented with 6 pairs of two–word followed by 6 pairs of complete sentence instructions.

1.4 DATA ANALYSIS

For each trial, the latency of response in hundredths of a second was obtained. In cases of an incorrect response (i.e. wrong key), the reaction time of that response was discarded and substituted by the mean reaction time of all correct responses in the language of the incorrect response. The data were analyzed in two separate 2 x 2 x 2 factorial designs with repeated measures on the last two factors. The factors were (a) English and French group, (b) English and French instructions, and (c) Block 1, consisting of trials 1–3, and Block 2, consisting of trials 4–6. The first analysis was computed for reaction time to the two word instructions while the second was computed for reaction time for the complete sentence instructions.

2.0 RESULTS

2.1 TWO WORD INSTRUCTIONS

The analysis of variance produced significant F–ratios for Group ($F = 4.41$, $df = 1$, $p < .05$), Block ($F = 31.39$, $df = 1$, $p < .01$) and the two-way interaction between Group and Language of Instruction ($F = 38.75$, $df = 1$, $p < .01$). Examination of the means revealed that the French *S* responded faster than the English *S*s (.48 vs .64) and that both groups responded faster in block 2 than in block 1 (.50 vs .62).

TABLE 1

ANALYSIS OF VARIANCE FOR TWO-WORD INSTRUCTION

Source	SS	df	MS	F
Between Subjects	97929.44	39		
GROUP (A)	10172.91	1	10172.91	4.405*
Subjects within	87756.53	38	2309.38	
Within Subjects	60539.16	120		
INSTRUCTION (B)	181.90	1	181.90	0.350
A x B	20133.17	1	20133.17	38.751**
B x Subjects	19742.75	38	519.55	
BLOCK (C)	5659.64	1	5659.64	31.389**
A x C	156.42	1	156.42	0.868
C x Subjects	6851.58	38	180.30	
B x C	233.77	1	233.77	1.185
A x B x C	84.10	1	84.10	0.426
BC x Subjects	7495.83	38	197.26	
TOTAL	158468.60	159		

*p < .05 **p < .01

The two-way interaction (see Figure 1) can be seen to be due to the differential response of both groups of *S*s to the two sets of instructions. French *S*s responded more quickly to French instructions (.36 vs .61) while English *S*s responded more quickly to English instructions (.54 vs .75).

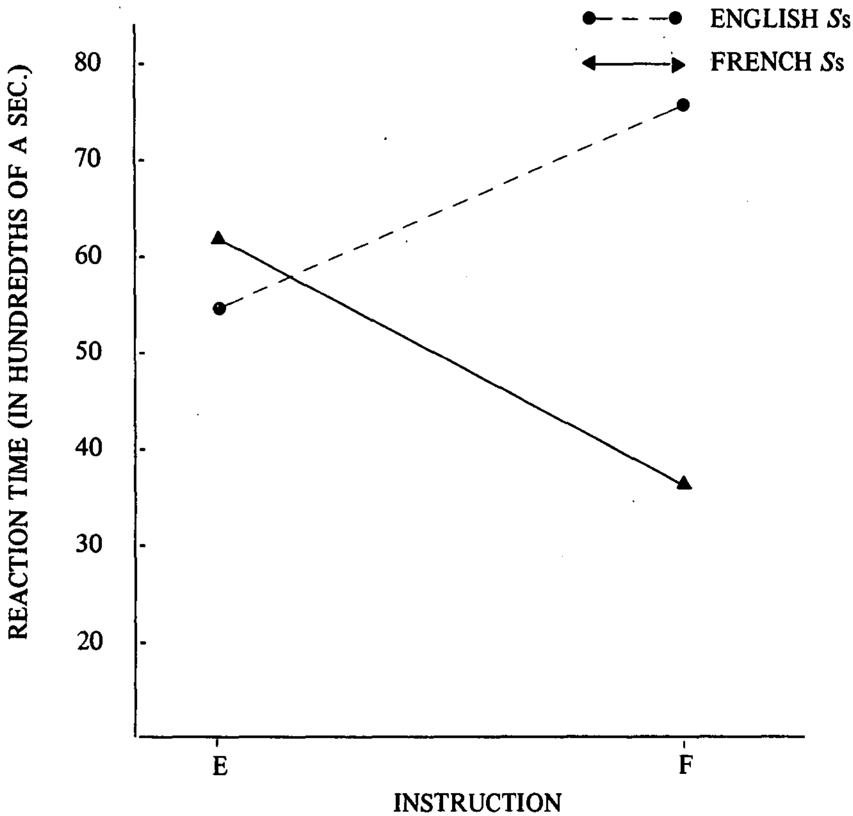

Fig. 1. Group by Instruction Interaction for Short Instruction

2.2 COMPLETE SENTENCE INSTRUCTIONS

The analysis of variance showed significant main effects for Group ($F = 6.02$, $df = 1$, $p < .05$) and Language of Instruction ($F = 14.63$, $df = 1$, $p < .01$). Inspection of the means shows that the French *S*s reacted faster than did the English (.29 vs .42), and that the general reaction time to English instructions was faster than to French instructions (.31 vs .39). In addition, 3 significant interaction effects were noted. The first (see Figure 2), between Group and Language of Instruction ($F = 63.74$, $df = 1$, $p < .01$) can be seen to be due to the differential responding times of English and French subjects to the two sets of instructions. While the French *S*s responded somewhat more quickly to French than to English instructions (.25 vs .33), their English counterparts reacted more quickly to English than to French (.30 vs .54). The second interaction (see Figure 3), between Group

TABLE 2

ANALYSIS OF VARIANCE FOR FULL-SENTENCE INSTRUCTIONS

Source of Variation	SS	df	MS	F
Between Subjects	46463.19	39		
GROUP (A)	6355.44	1	6355.44	6.021*
Subjects within	40107.75	38	1055.47	
Within subjects	36062.19	120		
INSTRUCTION (B)	2422.69	1	2422.69	14.629**
A x B	10566.00	1	10566.00	63.740**
B x Subjects	6293.17	38	165.61	
BLOCK (C)	430.99	1	430.99	1.928
A x C	1304.16	1	1304.16	5.999*
C x Subjects	8261.73	38	217.41	
B x C	514.81	1	514.81	3.456
A x B x C	617.80	1	617.80	4.147*
BC x Subjects	5660.84	38	148.97	
TOTAL	82525.39	159		

*$p < .05$ **$p < .01$

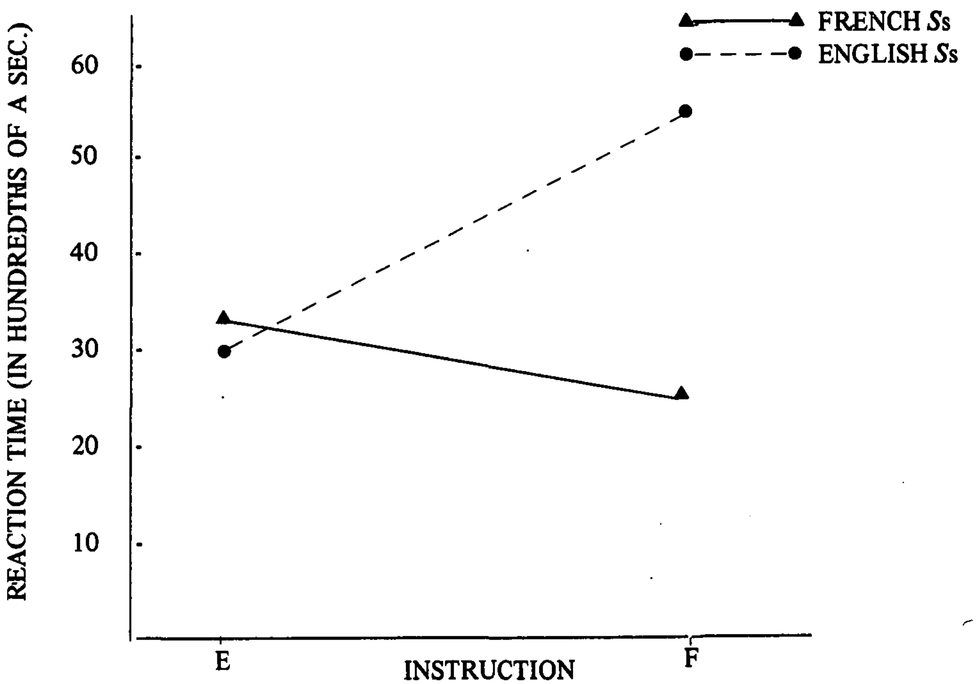

Fig. 2. Group by Instruction Interaction Time for Long Instruction.

and Block ($F = 6.00$, $df = 1$, $p < .05$), results from the fact that the response latency for English *S*s was greater in the first than in the second block (.47 vs .39), while that for French *S*s showed an opposite trend (.29 vs .31).

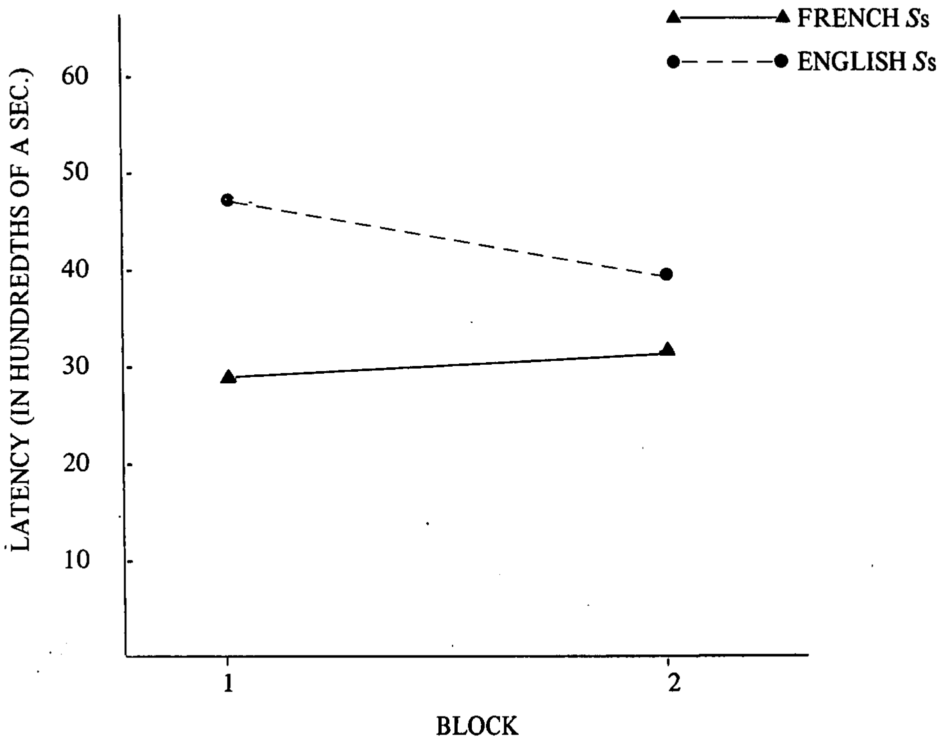

Fig. 3. Group by Block Interaction for Long Instruction.

The third interaction, (see Figure 4) among Group, Language of Instruction and Block ($F = 4.18$, $df = 1$, $p < .05$) can be seen to be due mainly to the performance of the French *S*s reacting to French instructions. Whereas the other 3 subgroups show a decrease in response latency from Block 1 to 2, this group shows a reverse effect.

3.0 DISCUSSION

The finding of major importance in this study is found in the two significant 2-way interactions between Group and Language of Instruction for both long and short instructions. *S*s were selected for this study on the basis of the differences in their experience with English and French. Because the French group had had a greater amount of experience with the French language, and the English group with the English Language, it was hypothesized that the latency of their reaction to the aural stimuli would vary as a function of this experience difference. The significant interactions between Group and Language of Instruction confirm this hypothesis. In both instances, the English *S*s reacted faster to English than to French, whereas the French *S*s reacted faster to French than to English. An analysis of the errors committed (i.e. wrong key depressed) indicated that there were no significant differences between the errors committed by either group to instructions in

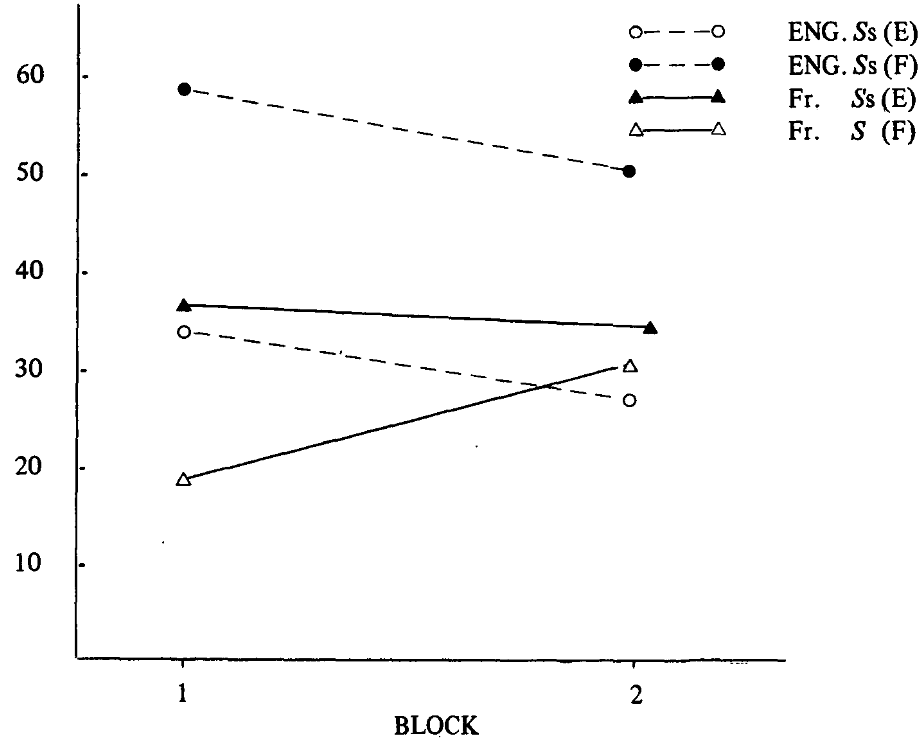

Fig. 4. Group by Instruction by Block Interaction for Long Instruction.

its first or second language. That is, French *S*s, although reacting more slowly to English than to French instructions, did not commit more errors in English than in French. These data suggest that, although individuals may be able to react accurately to stimuli in their first or second languages, the speed of this reaction time is governed, at least partially, by the amount of experience they have had with each language. In theory, the balanced bilingual should not demonstrate this latency difference. This research was conducted to determine whether bilingual individuals whose experience with their first language was much greater than with their second language, would demonstrate differences in reaction time to instructions in the two languages. Further research should now be carried out to determine if such differences in reaction time disappear when 'balanced bilinguals' react to such instructions.

It is interesting to note that there was a significant Language of Instruction effect for long but not for short instructions. This undoubtedly is due to the differences in the structure of the instruction in the two languages. Two cues (i.e. colour and direction) are needed to respond correctly. For the short instruction, in both languages, the direction (i.e. left or right) was followed by the colour. Thus, in English the instruction might read 'left red.' Its French equivalent would read 'gauche rouge.' In the full sentence instruction, however, the major components in the English instruction were the third and seventh words (i.e. Press the *red* button on the *left*). The full sentence French instruction, on the other hand, has its major instructional components as words four and six (i.e. Dépressez le bouton *rouge* à *gauche*). Thus, in English, one receives his first major instructional component earlier in the sentence, and two words removed from the other major component. As a result, one could expect a faster reaction time to the English than to the French instructions in the long but not short instruction condition, since one can assimilate the two cues separately in English but must assimilate both at nearly the same time in French.

A similar explanation might be used to account for the difference in reaction time to the short and long instruction. *S*s reacted more slowly to short (.56 sec.) than to full sentence instructions (.35 sec.). Since the clock did not start until the instruction had ended, full sentence instructions, especially in English, would allow *S*s to begin to search for the appropriate key before the clock started. The two-word instruction, on the other hand, would allow very little search time prior to the starting of the clock.

For both the short and long instruction, latency for French *S*s was less than for English *S*s. This may be due to other characteristics of the two groups. *S*s were selected on the basis of experience in the two languages, not on the basis of intelligence or absolute ability in the two language areas. The French-speaking *S*s were slightly older (23.7 yr. vs. 20.7 yr.), and had had more formal education (18 yr. vs. 16.2 yr.) than their English-speaking counterparts. Although years of schooling is not necessarily a good predictor of language efficiency, the difference in the present study may be significant. The French-speaking *S*s were doing work at the post-graduate level, while the English-speaking *S*s were still working at the undergraduate level. One can argue that the former have already undergone a more selective screening process in all areas, including language, than the latter. If so, one would expect a different overall performance from the two groups.

REFERENCES

DUNKEL, H. B. 1948. Second-Language Learning. New York: Ginn and Co.

ERVIN, S. 1961. Semantic shift in bilingualism. American Journal of Psychology. 74.233–41.

JOHNSON, G. B. 1953. Bilingualism as measured by a reaction time technique and the relationship between a language and a non-language intelligence quotient. Journal of Genetic Psychology. 82.3–9.

LAMBERT, W. E. 1955. Measurement of the linguistic dominance of bilinguals. Journal of Abnormal and Social Psychology. 50.197–200.

LAMBERT, W. E., HAVELKA, J., and R. C. GARDNER. 1959. Linguistic manifestations of bilingualism. American Journal of Psychology. 72.77–82.

LAMBERT, W. E., and MOORE, N. 1966. Word-association responses: Comparisons of American and French monolinguals with Canadian monolinguals and bilinguals. Journal of Personality and Social Psychology. 3.313–20.

MACNAMARA, J. 1967a. The bilinguals' linguistic performance. Journal of Social Issues. 23.58–77.

RAO, T. S. 1964. Development and use of 'Direction Test' for measuring degree of bilingualism. Journal of Psychological Researches. 8.114–9.

SCHERER, G. A. C., and M. A. WERTHEIMER. 1964. Psycholinguistic Experiment in Foreign-Language Teaching. New York: McGraw-Hill.

WARSHAW, J. 1924. Automatic reactions in practical foreign language work. Modern Language Journal. 9:151–8.