LISTENERS' RESPONSES TO EXTRANEOUS SIGNALS COINCIDENT WITH ENGLISH AND FRENCH SPEECH

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ABSTRACT - English and French listeners performed two tasks - click location and speeded click detection - with both English and French sentences, closely matched for syntactic and phonological structure. Clicks were located more accurately in open- than in closed-class words in both English and French; they were detected more rapidly in open- than in closed-class words in English, but not in French. The two listener groups produced the same pattern of responses, suggesting that higher-level linguistic processing was not involved in these tasks.

INTRODUCTION

Psycholinguists study the *human* language processing system. Humans are capable of acquiring any language to which they are exposed as children; the language processing system is not biased towards the processing of any one language rather than another. Therefore it is very important that conclusions drawn from psycholinguistic experiments be free of confounding factors specific to one language or linguistic community.

Cross-linguistic comparisons have a crucial role to play in ensuring the universality of psycholinguistic arguments. There are several ways in which cross-linguistic comparisons can be exploited (Cutler, 1985); the one which will be relevant here is their function as an essential control condition. The classic case is an effect observed in a psycholinguistic experiment which allows of two explanations: one in terms of low-level auditory factors, and one in terms of higher-level linguistic processing. The correct explanation can be found by testing the same materials on subjects who do not speak the language. Such subjects would presumably have the same auditory system as the subjects in the original experiment, but would be unable to process the speech linguistically; in other words, they should be equally susceptible to auditory effects but impervious to linguistic effects.

This kind of cross-linguistic comparison has been carried out by, for example, Cutler, Mehler, Norris and Segui (1987), and Otake, Hatano, Cutler and Mehler (1993). In both cases the failure of an effect to re-appear in subjects who did not speak the language of the stimulus materials confirmed an explanation invoking linguistic processing.

The tasks used in the present experiments involve detection of an extraneous signal - a click - coincident with a spoken sentence. Subjects can be asked (a) to locate the click - i.e. to judge exactly where in the sentence it occurred, given a written transcript of the speech, or (b) to produce a speeded response signalling detection. Click detection tasks of both kinds were used quite widely in psycholinguistics in the 1960s and 1970s (e.g. Abrams & Bever, 1969; Holmes & Forster, 1970, 1972; Seitz & Weber, 1974). Cutler and Norris (1979) summarised the results of such experiments and observed that detection of extraneous signals tended to produce a different pattern of results than was produced by tasks involving detection of some sentence-internal unit (e.g. a phoneme, syllable or word). They urged caution in the interpretation of click experiments: "Before monitoring for nonlinguistic targets can be considered a useful measure, more information is required about exactly what processing operations it reflects and in what manner it reflects them" (1979: 129).

Click detection studies fell out of favour for some years; however, they are now being revived in a number of laboratories. The present study attempts an initial approach to garnering the further information on the task for which Cutler and Norris (1979) called.

METHOD

Materials

Ten sentences were constructed in each of English and French. The sentences were previously used in a study of perceptual isochrony in these languages, and a complete description plus a list of the sentences may be found in the published report of that study (Scott, Isard & de Boysson-Bardies, 1985). The syntactic, semantic and phonological structure of the sentences was - subject to the constraints of the respective languages - closely matched across the two sets of materials (e.g. "The play will please both Peter and Paul; La pièce va plaire à Pierre et à Paul; The brisket is better at the butchers in Bognor; Les brioches sont bonnes dans la brasserie à Boulogne.").

The sentences were recorded by female native speakers of British English and of French. Each sentence was digitised and copied. A click was placed in each digitised version. The click was constructed by setting to a constant amplitude seven samples of a 44.1 kHz digitised version of the sentence, which were then low-pass filtered at 10 kHz on playback. Clicks were aligned with the centre of a vowel. Because these materials had originally been constructed for another purpose, it was not possible to manipulate the variables of interest in every pair of sentences in the same way. The analyses reported here concern a subset of seven cross-language sentence pairs for which the following description holds true. In one copy of each sentence the click was placed in an open-class word, either a noun or a verb (in the above examples: "please, plaire, Bognor" and "Boulogne" respectively; in the latter two the click occurred in the first syllable). In the other copy of each sentence the click occurred on a closed-class word; an article, conjunction, possessive pronoun or preposition (in the above examples: "and, à, the" and "la" respectively). The number of syllables was matched across each sentence pair, and clicks occurred in the same syllable position in each member of a pair (thus, for instance, the closed-class click in "La pièce va plaire à Pierre et à Paul" occurred in the *second* occurrence of "à", which, like "and" in the matching English sentence, was the penultimate syllable in the sentence).

Two tapes were constructed, one in English and one in French. Each tape contained three occurrences of each version of each of the ten sentences for that language, i.e. a total of 60 trials. In addition, three practice trials occurred at the beginning of each tape. The order of the sentences on each tape was randomised, subject only to the constraint that any one sentence did not occur twice within any four trials. On the tapes the sentences occurred on one channel and the clicks on the other. There was a 4 second gap between trials.

Procedure

Two types of task were used: judgement of where in the sentence the click occurred, and speeded response signalling detection of the click. In the former case we measured listeners' accuracy in locating the click, and in the latter their reaction time to detect it.

In the location task, subjects listened to the tape and marked the location of the click on a written transcript. They were instructed not to look at the sentence until after they had heard it, and then to mark the location of the click with a line through the sentence. They were specifically instructed that the line could be drawn through a letter if they thought the click had occurred coincident with a particular sound, or between letters or words.

In the reaction time task subjects listened to the sentences with no transcript. They were instructed to respond as fast as possible once they had detected a click. The response was made by pressing a key with the preferred hand. Timing and data collection were controlled by computer.

The sentences were presented over headphones with the speech to the dominant side (i.e. the right ear for right-handers) and the click to the non-dominant side. Each subject performed only one type of task, but heard both tapes, i.e. responded to sentences both in the native and the non-native language. Subjects in both tasks were tested individually or in groups of up to four. Testing of the English subjects took place at the University of Sussex, testing of the French subjects at the Applied Psychology Unit in Cambridge. At both locations the testing was conducted in a sound-dampened room. All subjects were paid a small honorarium for taking part in the study.

Subjects

The English listeners were undergraduates at the University of Sussex. 12 subjects took part in the location task and 16 in the reaction time task. The French listeners were advanced secondary school students newly arrived at Cambridge language schools. 14 took part in the location task and 12 in the reaction time task. No listeners were highly proficient in the non-native language.

RESULTS

1. Location task

The subjects' responses were classified according to whether they were (a) accurately located in the vowel, (b) in the same syllable, (c) at the margin of the correct syllable, (d) one syllable away from the correct location, or (e) more than one syllable away. For simplicity, responses classified as (a) and (b) were pooled into a single category of "accurate" responses, which could then be compared with the category "inaccurate", comprising the pooled responses classified as (d) and (e).

Table 1 presents the proportion of accurate responses, located in the correct syllable - i.e. (a) and (b) responses - versus inaccurate responses, at least one syllable away - i.e. (d) and (e) responses - for English versus French listeners and for English versus French stimulus materials. Because of the omission of (c) responses, the proportions do not sum to 1. It can be seen that click location was far more accurate in open-class than in closed-class words, and that this pattern held true for all combinations of listener language and stimulus language. Chi-squared tests showed that the word class effect was statistically reliable at the .001 level for each combination of listener language and stimulus language (English listeners: χ^2 [1] = 155.3 for English sentences, χ^2 [1] = 215.1 for French sentences; French listeners: χ^2 [1] = 115.1 for English sentences, χ^2 [1] = 88.7 for French sentences).

	English listeners				French listeners			
	English sentences		French sentences		English sentences		French sentences	
	Acc	Inacc	Acc	Inacc	Acc	Inacc	Acc	Inacc
Open Class	.71	.12	.67	.24	.59	.22	.64	.19
Closed Class	.21	.46	.23	.60	.10	.62	.06	.67

Table 1. Proportion of accurate versus inaccurate click location judgements as a function of open versus closed word class, separately for English and French listeners and for English and French sentences.

	English listeners				French listeners			
	English sentences		French sentences		English sentences		French sentences	
	Acc	Inacc	Acc	Inacc	Acc	Inacc	Acc	Inacc
Open Class	.69	.12	.67	.26	.61	.21	.60	.20
Closed Class	.18	.52	.25	.51	.08	.66	.02	.72

Table 2. Proportion of accurate versus inaccurate click location judgements as a function of open versus closed word class, separately for English and French listeners and for English and French sentences; first presentation of each sentence only.

Because the closed-class words consist of shorter syllables than the open-class words, it might be argued that the scoring system is biased towards greater accuracy in the case of open-class words. However, it was also the case that for each combination of listener language and stimulus language the open-class responses in category (a) outnumbered the closed-class responses in categories (a), (b) and (c) combined.

It will be recalled that each stimulus sentence was presented three times. The proportions in Table 1 are based on sums across all three presentations. A separate analysis was undertaken of the first presentation only. The results are shown in Table 2. This analysis produced exactly the same pattern of statistical significance as the analysis of all trials (for English listeners, χ^2 [1] = 59.5 for English sentences, χ^2 [1] = 78.8 for French sentences; for French listeners, χ^2 [1] = 43.9 for English sentences, χ^2 [1] = 20.0 for French sentences; $p < .001$ for all values).

2. Reaction time task

Table 3 presents the mean reaction time to clicks in open-class and closed-class items as a function of listener language and stimulus language. It can be seen that both groups show faster response times to clicks in open-class words than to clicks in closed-class words in the English sentences, but hardly any difference in response time as a function of word class in the French sentences. An analysis of variance produced a significant interaction between word class and stimulus language ($F1$ [1,26] = 6.81, $p < .02$), but this effect did not interact with listener language ($F < 1$). The word class effect was significant for the English sentences for both English listeners (t [15] = 5.09, $p < .001$) and French listeners (t [11] = 2.9, $p < .02$), but was not significant for the French sentences either for English listeners (t [15] = 1.5, $p > .1$) or French listeners t [11] < 1).

Again, a separate analysis was undertaken of the first presentation only. The results are shown in Table 4. The same pattern of statistical significance was again observed as in the analysis of all trials; the word class effect was significant for the English sentences for both English listeners (t [15] = 2.45, $p < .03$) and French listeners (t [11] = 2.3, $p < .05$), but failed to reach significance for the French sentences either for English listeners (t [15] = 1.85, $p > .08$) or for French listeners t [11] < 1).

	English listeners		French listeners	
	English sentences	French sentences	English sentences	French sentences
Open Class	221	244	244	270
Closed Class	244	252	270	268

Table 3. Click detection response time (msec) as a function of open versus closed word class, separately for English and French listeners and for English and French sentences.

	English listeners		French listeners	
	English sentences	French sentences	English sentences	French sentences
Open Class	215	249	250	295
Closed Class	237	257	277	305

Table 4. Click detection response time (msec) as a function of open versus closed word class, separately for English and French listeners and for English and French sentences; first presentation of each sentence only.

3. Durational measurements

The word class variable is strongly correlated with phonological factors, at least in English (Cutler, 1993): open-class words must contain at least one strong syllable - i.e. a syllable with a full vowel, while closed-class words may be realised as weak syllables containing only a reduced vowel. Such differences are less marked in French (Delattre, 1966). In order to assess the possible contribution of the way the vowels in each type of word are realised, we measured the duration of each vowel onto which a click had been superimposed. In English, the vowels in open-class words were on average more than twice as long as the vowels in closed-class words, and the length difference across items was statistically significant (t [6] = 5.76, $p < .001$). In French, the difference as a function of word class, although for most sentences it was in the same direction as the English difference, was less marked, and did not reach statistical significance (t [6] = 1.94, $p > .1$)

A correlation analysis was carried out on the difference between the durations of vowels in open- versus closed-class words and the difference in location accuracy scores and response times for clicks in open- versus closed-class words, across items, listener groups and trials. No significant correlation was observed for the location accuracy measures. However, there was a marginally significant correlation between vowel duration and response time (r [83] = .18, $p < .05$ one-tailed): the larger the difference in vowel duration, the larger the difference in RT.

CONCLUSION

The most important outcome of this study is that the pattern of results was essentially identical across the two listener groups. That is, click location responses are more accurate in open-class than in closed-class words regardless of whether or how well the listener understands the language. Likewise, speeded click detection is faster in open- than in closed-class words in English, but not in French, and again this holds true regardless of the listener's level of understanding.

The conclusion is unavoidable, therefore, that these response patterns do not reflect higher-level linguistic processing. The word class difference *per se* is not responsible for the differences in accuracy and response time. Instead, an explanation must be sought in some lower-level reflection of the word class distinction.

The results of our measurements of vowel duration suggest a tentative answer to the question of what this lower-level effect might be. In English but not in French, vowels in open-class words are significantly longer than vowels in closed-class words. In English but not in French, clicks in open-class words are detected significantly more rapidly than clicks in closed-class words. This suggests that response time to detect clicks coincident with vowels is sensitive to the vowels' duration (perhaps because a click is effectively more salient against a steady-state portion than against a more rapidly varying portion of a speech signal). The significant correlation which we observed between differences in vowel duration and in response time is consistent with this interpretation.

On the location task, listeners were more accurate locating clicks in open- than in closed-class words in both languages. The location accuracy data, however, showed no relationship with vowel duration. It is noteworthy that in both languages the open-class words were phonologically more complex than the closed-class words. It may be the case that listeners simply prefer to locate clicks in more phonologically complex syllables. This interpretation is of course in need of empirical test.

We conclude, then, that click detection tasks are highly sensitive to low-level factors and that caution should be exercised in drawing conclusions about higher-level processing from such tasks. Note that the pattern of results with one language group alone could have produced a misleading conclusion. In the experiments with English listeners, for example, we observed a difference in response time to open- versus closed-class words in English sentences but not in French sentences. Alone, this result would appear indicative of higher-level processing being involved in the response time effect. Had the French listeners shown a processing difference between open- and closed-class words in the French but not in the English materials, such a conclusion would indeed have been justified. However, the French listeners in fact showed exactly the same pattern as English listeners on both sets of materials. Thus the cross-linguistic comparison has proved invaluable in ruling out what would have been an unwarranted conclusion.

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