PERCEPTION OF VOWEL QUALITY BY GERMAN-ENGLISH BILINGUALS

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ABSTRACT

German-English bilinguals' labelling of the front vowel space in each of their language modes was investigated using a synthesised vowel continuum. Results showed that bilinguals achieved native-like performance in the English condition, but that their performance in German was affected by their experience in English.

INTRODUCTION

This study examines the extent to which perceptual categories for vowels are language-specific, and investigates how bilinguals process potential conflicts between the phonological categories of their two languages.

The conflict investigated in the present experiment was the division into phonological categories of the front vowel space. Both English and German have an open-mid front vowel /e/ and an open central vowel /a/ which are phonetically similar in both languages [1]. (The symbol /a/ will be used for the vowel in German *Bad* and in English *but* (usually transcribed /ʌ/), to avoid using different symbols for similar vowels).

However, the English front open vowel /æ/ has no equivalent in German, and evidence indicates that German speakers have difficulty in developing a stable category for English /æ/, and either identify it with an adjacent German vowel [1], or use a category based on different acoustic dimensions to those of English natives [2].

The question of interest in the present study was to what extent the German-English bilinguals had succeeded in acquiring and maintaining native-like categories for the front vowel space in each of their languages, or whether the co-existence of the two systems affected perceptual categories in one or both of the languages.

METHODOLOGY

Test material

The stimuli consisted of synthesised CVC syllables in which the formant structure of the vowel portion was varied to create a continuum between three fixed points corresponding to /e æ a/.

The vowel portions of the three fixed points, based on acoustic measurements of similar syllables spoken by native English and German speakers, were synthesised through the cascade branch of a Klatt synthesis system. The acoustic characteristics of these three vowels were as follows:

/e/ F1 650 Hz, F2 1900 Hz, F3 2640 Hz; F4 4000 Hz; F5 4500 Hz
/æ/ F1 800 Hz, F2 1550 Hz, F3 2460 Hz; F4 4000 Hz; F5 4500 Hz
/a/ F1 700 Hz, F2 1250 Hz, F3 2550 Hz; F4 4000 Hz; F5 4500 Hz

The fundamental frequency for all three vowels was 100 Hz at onset and 85 Hz at offset; the amplitude was 45 dB and the duration of the vowel was 100 msecs.

A continuum of vowel quality was then created by logarithmic interpolation of a further five values for F1, F2 and F3 between each pair of fixed points. Other characteristics were held constant. This resulted in a thirteen-point continuum of formant structure, ranging from /e/ through /æ/ to /a/.

These vowel tokens were inserted between consonants synthesised through the parallel branch of a Klatt synthesis system, to produce CVC syllables. The consonant frame used for the English condition was /b_t/, giving the possible English words *bet*, *bat* and *but*; for German the context was /f_st/, giving the possible German words *fest* and *fast*.

The entire continuum consisted of 13 synthetic syllables, which were presented in 10 randomised blocks, giving a total of 130 stimuli, preceded by a practice block consisting of an additional 13 randomised steps.

Subjects

Subjects were 12 German-English bilinguals with a range of language-backgrounds and patterns of acquisition. Some were childhood bilinguals; others had acquired the second language as adults. All spoke both languages to a very high level, had spent time living in both countries and used both languages on a regular basis. Bilingual subjects were matched for language-dominance on the basis of data extracted from a questionnaire (after [3]).

In addition six monolingual speakers of each language were tested. The English monolinguals were first year Speech Science students at University College London; the German monolinguals were students of the Fachbereich Computerlinguistik at the Universität des Saarlandes in Saarbrücken. All subjects were paid for their participation.

Test procedure

Testing took place in soundproofed rooms at UCL, and at the University of Saarbrücken.

Monolingual subjects were tested in a single session, and bilingual subjects in two sessions, one in each language. Half the bilinguals were tested in English first, the other half in German first; in either case, the two sessions were conducted at least two weeks apart.

The tests were conducted as part of a wider series of tests, and considerable care was taken to place subjects in the appropriate language mode. All conversation and instructions took place in the test language, and subjects were asked to read aloud several texts in the test language before the experiment began.

The stimuli were played on a Marantz audio cassette recorder, and presented to subjects binaurally via Sennheiser HD414 headphones. The task was an open-labelling one: subjects were asked to write down on the response sheet the word in the test language which most resembled each stimulus heard; the practice block was conducted first to ensure that subjects had understood the task and had the chance to familiarise themselves with the material.

RESULTS

A Maximum Likelihood Estimate procedure was used to produce a cumulative normal function (probit analysis) for each subject's set of responses, and the parameters of phoneme boundary (PB) and function gradient (slope) were extracted to characterise the categories perceived by the subjects. Mean results for each group were then established.

Table 1. Location of phoneme boundaries and function gradient for different subject groups

		/e-æ/	/e-a/	/æ-a/
Eng mono	PB	4.127		8.199
	slope	2.302		-2.650
Ger mono	PB		6.468	
	slope		1.383	
Eng biling	PB	3.948		8.306
	slope	1.748		-2.348
Ger biling	PB		5.725	
	slope		2.620	

The most immediately striking feature of this data is the clear split between the responses in the English condition, in which all subjects perceived two phoneme boundaries, and the responses in the German condition in which all subjects perceived one boundary only.

Figures 1-4 below characterise the different categories used in each of the language conditions. The boundaries between the three categories for the English monolinguals are marked by steep curves and low inter-subject variability (as measured by the one standard deviation error bars). This suggests that for the English monolinguals the three categories spanned by the continuum were stable and clearly defined, with sharp boundaries.

For German monolinguals the boundary between the two categories in the German condition is marked by a much shallower curve, with a high degree of inter-subject variability. This suggests that that part of the continuum corresponding to English /æ/ was not reliably identified by German subjects. The location of the phoneme boundary in German confirms this impression, since it occurred between steps 6 and 7, which corresponds exactly to the midpoint of the continuum, the default location for a boundary which is not mediated by phonetic considerations [4].

The labelling behaviour of the bilinguals is more complex. Although all bilinguals had a category corresponding to English /æ/, the boundary curves are shallower than those for English

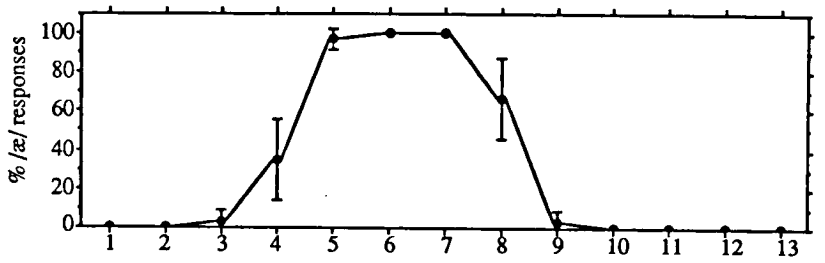

Figure 1. % /æ/ responses: English monolinguals

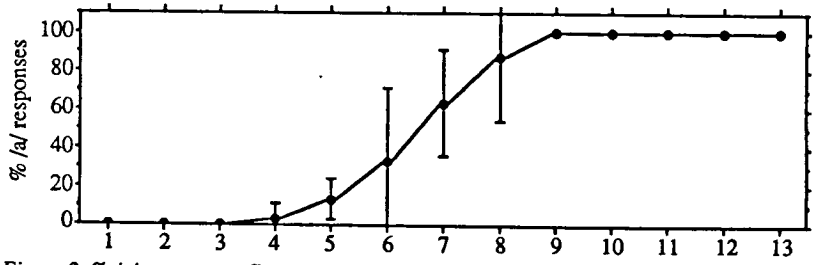

Figure 2. % /a/ responses: German monolinguals

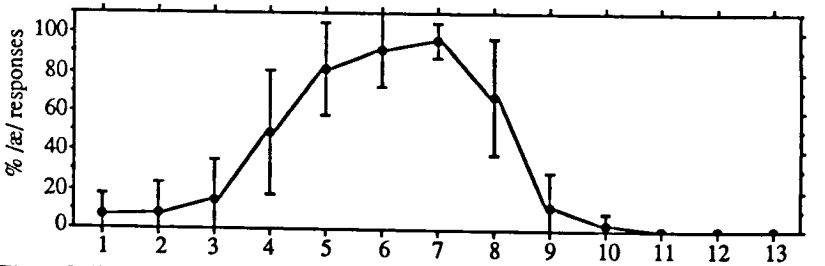

Figure 3. % /æ/ responses: Bilinguals English condition

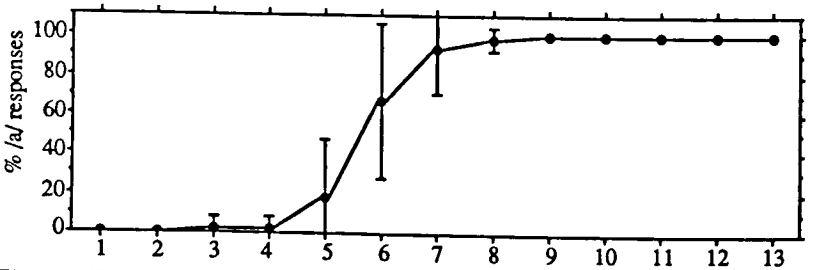

Figure 4. % /a/ responses: Bilinguals German condition

monolinguals, and characterised by a higher degree of variability, particularly for the /e-æ/ boundary. This suggests that the bilinguals' categories in the English condition were less stable than those of the monolinguals.

A further interesting finding is the labelling behaviour of the bilinguals in the German condition. Unlike the German monolinguals, for whom the /æ/ category was simply divided at the midpoint of the continuum, the boundary curve for bilinguals in the German condition shows a clear skew to the left, and is steeper than that of the monolinguals. This suggests that the bilinguals' categorisation of the front open vowel in the German condition was mediated by their linguistic experience of the English /æ/ category, although this would not have been relevant to the German task.

A statistical analysis in the form of a t-test for two independent samples was performed on the values for phoneme boundary and slope extracted from the MLE procedure. Comparison of the bilinguals' results in each language condition confirm that they were able to match the performance of the English monolinguals in labelling English categories. There was no significant difference between monolinguals and bilinguals in the English condition either with regard to the location of phoneme boundary for the /e-æ/ boundary ($t=0.50$ ($df=16$) $p>0.05$) nor the /æ-a/ boundary ($t=0.48$ ($df=16$) $p>0.05$). The slope of the two boundaries for the bilinguals also did not differ significantly from that of the monolinguals ($t=1.22$ ($df=16$) $p>0.05$ and $t=0.96$ ($df=16$) $p>0.05$ respectively).

However, in the German condition, the performance of the bilinguals did differ significantly from that of the monolinguals, both for PB ($t= 2.89$ ($df=16$) $p<0.05$) and slope ($t=2.42$ ($df=16$) $p<0.05$).

DISCUSSION

The fact that all bilinguals perceived the appropriate number of categories in each language condition shows that they were able to code-switch in their perception according to the language-set they were in. This clear between-language difference is all the more striking in view of the fact that the task was an open labelling one, which did not predispose subjects to choose a particular number of categories for their responses.

Moreover, the finding that the group results for bilinguals in the English condition matched the performance of English monolinguals shows that the categories they had developed were sufficienctly accurate and stable to enable them reliably to label vowels corresponding to the English sequence /e-æ-A/. Since most of the subjects were not childhood bilinguals, this suggests that a late age of learning is not necessarily an obstacle to the formation of new phonological categories.

In contrast, the findings for the German condition show that bilinguals as a group do differ from monolinguals in their categorisation of stimuli corresponding to English /æ/. The leftward shift in the bilingual labelling function as compared to the German monolingual labelling function suggests that the bilinguals are using phonemic criteria in their labelling behaviour, since use of acoustic criteria would produce a boundary at the midpoint of the continuum. Since there are no German phonetic criteria which are relevant to this category, it appears that the bilinguals' experience with English influenced their categorisation of the continuum in the German condition.

It seems that the bilinguals' ability to acquire and maintain English categories in the face of the competing German standard was matched by a move away from monolingual categorisation in the German condition. In other words, it is possible to acquire native-like categories for a second language, but that improved performance in the L2 may be matched by decreasing nativeness in L1.

ACKNOWLEDGMENT

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REFERENCES

[1] Barry, W.J. (1989), "Perception and production of English vowels by German learners: Instrumental-phonetic support in language teaching", *Phonetica*, vol. 46, pp. 155-168.

[2] Bohn, O.-S. and Flege, J. (1990), "Interlingual identification and the role of foreign language experience in L2 vowel perception", Applied Psycholinguistics, vol. 11, pp. 303-328.

[3] Hazan, V. and Boulakia, G. (1993), "Perception and production of a voicing contrast by French-English bilinguals", Lang. & Speech, vol 36 (1), pp. 17-38.

[4] Rosen, S. (1979), "Range and frequency effects in consonant categorisation", *J. Phonetics*, vol. 7, pp. 393-402.