

## Two languages – one brain

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### Abstract

Studies on bilingual speech processing have implied that bilinguals may either have two separate or one intertwined system. These findings have been obtained by multiple methods using various types of bilinguals. Our study compared monolinguals and two types of bilinguals. We used the same methods for all groups, i.e. we measured attentive identification scores and preattentive discrimination. Our results show that bilinguals process speech sounds differently from monolinguals, and more importantly, that there is a difference between the two types of bilinguals. We suggest that dominant bilinguals have two separate phonological systems, while balanced bilinguals have one uniform system.

Key words: speech perception, bilingualism, mismatch negativity.

### Introduction

Earlier research has revealed that speech sound processing is language-specific (Näätänen et al. 1997). This is seen in the mismatch negativity (MMN) component of the event-related potentials (ERPs), which has an extensive amplitude and short latency when a native language category boundary is crossed. The acquisition of new non-native speech sounds may also be studied by using the MMN response. Representations may emerge in immigration (Winkler et al. 1999) and in early exposure (Peltola et al. 2005), while tentatively not in classroom (Peltola et al. 2003). Bilingual speech processing studies have also considered the neural organisation of the two languages: Winkler et al. (2003) showed that immigrants had similar kinds of MMN-responses to both their languages irrespective of the linguistic context. The “one-store model” was also apparent in Chee et al. (1999) study on early bilinguals (pre 7 years). In contrast, Peltola et al. (2005) suggested that classroom learners have two separate phonological systems, which is in accordance with the “two-store-model” shown by Paulesu et al. (2000). One view is also that there is a language “switch” as indicated by the presence of additional neural control (Hernandez et al. 2001). Methodology may explain some of the contradictions, since procedures either keep the languages apart,

or they demand switching. While subjects may all be bilinguals by one definition, their linguistic backgrounds vary. We performed the same protocol on two types of Finnish-Swedish bilinguals and monolingual Finns. The results indicate the significant effect of the linguistic background on neural phonological organisation.

## Methods

Three groups of right handed young adult subjects with normal hearing participated in this study: Group 1: 10 native speakers of Finnish (Monolinguals), Group 2: 12 balanced Finnish-Swedish bilinguals (Balanced), who had acquired both languages from birth and Group 3: advanced Finnish University students of Swedish (Dominant).

The stimuli consisted of 18 synthetic vowels from the closed vowel continuum divided into two categories in Finnish, /y/-/u/, and three in Swedish, /y/-/u/-/u/. The identification test showed the boundary location and steepness for each subject. We selected a stimulus pair individually so that it crossed the boundary in Finnish, but was within the Swedish /u/. Monolinguals participated once, while the bilingual groups twice (Finnish and Swedish researcher). The hypothesis was that, if the two phonological systems are distinct, the MMN to the same stimulus pair could have an extensive amplitude and a short latency in the Finnish context (phonemic), but a reduced amplitude and a long latency in the Swedish context (non-phonemic).

We registered EEG in the oddball paradigm using Synamps amplifier. We analysed the MMN peak latency (150-300ms) from one electrode and the mean amplitude from Fz, Cz, F3, F4, C3, and C4 with two Time windows (180-230ms, 230-280ms). The data was statistically analysed with Repeated measures ANOVA. The category boundary location and steepness were determined with logit transformation using SPSS.

## Results

When the Monolingual and Balanced bilingual data were compared, the latency analysis showed the main effect of Group ( $f(1,20)=4.753, p=0.041$ ) revealing the later response of the Balanced bilinguals. This result was supported by the amplitude analysis, which showed the interaction Group x Time window ( $f(1,20)=8.399, p=0.009$ ). The main effect of Group ( $f(1,20)=4.834, p=0.040$ ) suggested an overall reduced amplitude in the responses by the Balanced bilinguals, see Figure 1.

When the two types of bilinguals were compared, the latency analysis revealed the main effect of Group ( $f(1,19)=11.381, p=0.003$ ) implying a longer latency of the MMN by the Balanced bilinguals. This was also

apparent in the amplitude analysis showing the Group x Context language x Time window ( $f(1,19)=5.639, p=0,028$ ) interaction. Most importantly, the Dominant bilinguals showed the main effect of Context language ( $f(1,8)=8.843, p=0.018$ ), while there was no such effect in the Balanced bilinguals (Group x Context language ( $f(1,19)=5.369, p=0,032$ )). This difference is demonstrated by the almost complete lack of a response by the Dominant bilinguals to the stimulus pair in the Swedish context (non-phonemic) in comparison with the extensive MMN in the Finnish context (phonemic). The Balanced bilinguals have similar kinds of slow latency responses irrespective of the linguistic context. This result was also supported by the ID-results, which showed that while the Finnish category boundary locations matched, the steepness value was lower in the Balanced bilinguals, implying hesitation (Group x Context language ( $f(2,18)=4.737, p=0.022$ )).

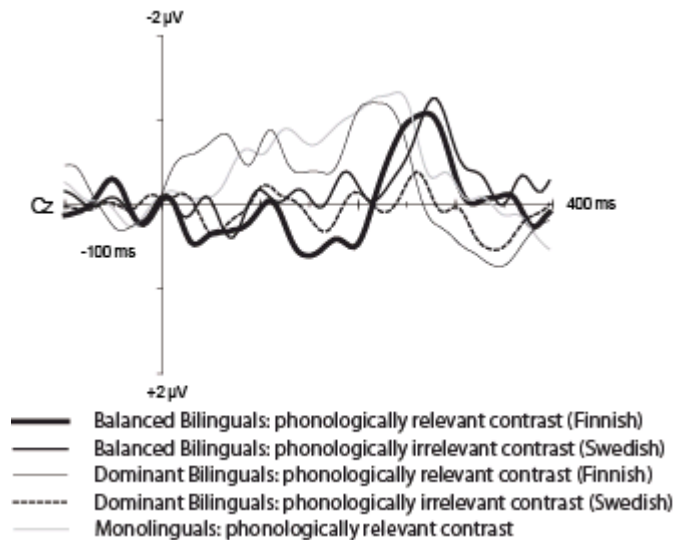


Figure 1. The MMN responses of the Monolingual, Balanced and Dominant bilingual groups to the same vowel pair.

## Conclusions

Our results clearly indicate that monolinguals perceive speech sounds differently from bilinguals, which is evident from the lateness of the Balanced bilingual MMN response in comparison with that of the Monolingual group. More importantly, preattentive discrimination is dependent upon the type of bilingualism, which is obvious from the massive difference in the MMN of the bilingual groups in the perception of the pair

in the Swedish context, as well as from the behavioural transfer from Swedish to Finnish in Balanced bilinguals. This is further supported by the similarity of the Dominant bilingual and the Monolingual MMN to the native vowels. Therefore, Balanced bilinguals process speech sounds similarly irrespective of the language of the immediate vicinity, while Dominant bilinguals are context-sensitive.

We argue that Balanced bilinguals do not dissociate between their two languages even at the preattentive level of perception, which suggests that they have one intertwined phonological system. In contrast, Dominant bilinguals are able to block their maternal language in preattentive perception, which implies two separate phonological systems.

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### References

- Chee, M.W.L., Caplan, D., Soon, C.S., Sriram, N., Tan, E.W.L., Thiel, T., Weekes, B. 1999. Processing of visually presented sentences in Mandarin and English studied with fMRI. *Neuron* 23, 127-137.
- Hernandez, A.E., Dapretto, M., Mazziotta, J., Bookheimer, S. 2001. Language Switching and language representation in Spanish-English bilinguals: an fMRI study. *NeuroImage* 14, 510-520.
- Näätänen, R., Lehtokoski, A., Lennes, M., Cheour, M., Huotilainen, M., Iivonen, A., Vainio, M., Alku, P., Ilmoniemi, R.J., Luuk, A., Allik, J., Sinkkonen, J., Alho, K. 1997. Language-specific phoneme representations revealed by electric and magnetic brain responses. *Nature* 385, 432-434.
- Paulesu, E., McCrory, E., Fazio, F., Menoncello, L., Brunswick, N., Cappa, S.F., Cotelli, M., Cossu, G., Corte, F., Lorusso, M., Pesenti, S., Gallagher, A., Perani, D., Price, C., Frith, C.D., Frith, U. 2000. A cultural effect on brain function. *Nature Neuroscience* 3, 91-96.
- Peltola, M.S., Kujala, T., Tuomainen, J., Ek, M., Aaltonen, O., Näätänen, R. 2003. Native and foreign vowel discrimination as indexed by the mismatch negativity (MMN) response. *Neuroscience Letters* 352, 25-28.
- Peltola, M.S., Kuntola, M., Tamminen, H., Hämäläinen, H., Aaltonen, O. 2005. Early exposure to non-native language alters preattentive vowel discrimination. *Neuroscience Letters* 388, 121-125.
- Winkler, I., Kujala, T., Tiitinen, H., Sivonen, P., Alku, P., Lehtokoski, A., Czigler, I., Csépe, V., Ilmoniemi, R.J., Näätänen, R. 1999. Brain responses reveal the learning of foreign language phonemes. *Psychophysiology* 36, 638-642.
- Winkler, I., Kujala, T., Alku, P., Näätänen, R. 2003. Language context and phonetic change detection. *Cognitive Brain Research* 17, 833-844.