Journal of Memory and Language 87 (2016) 59–70

Contents lists available at ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jml

Cross-language and cross-modal activation in hearing bimodal bilinguals

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ARTICLE INFO

Article history:
Received 10 July 2015
revision received 14 October 2015

Keywords:
Cross-language activation
Cross-modal activation
Bimodal bilingualism
Sign language

ABSTRACT

This study investigates cross-language and cross-modal activation in bimodal bilinguals. Two groups of hearing bimodal bilinguals, natives (Experiment 1) and late learners (Experiment 2), for whom spoken Spanish is their dominant language and Spanish Sign Language (LSE) their non-dominant language, performed a monolingual semantic decision task with word pairs heard in Spanish. Half of the word pairs had phonologically related signed translations in LSE. The results showed that bimodal bilinguals were faster at judging semantically related words when the equivalent signed translations were phonologically related while they were slower judging semantically unrelated word pairs when the LSE translations were phonologically related. In contrast, monolingual controls with no knowledge of LSE did not show any of these effects. The results indicate cross-language and cross-modal activation of the non-dominant language in hearing bimodal bilinguals, irrespective of the age of acquisition of the signed language.

Introduction

A central question in bilingualism is whether the processing of one language necessarily involves activating the other, or whether the two languages are accessed independently. Some neuroimaging studies have revealed overlapping activation of the same brain regions for both languages (e.g., Chee, Tan, & Thiel, 1999; Illes et al., 1999; Klein, Milner, Zatorre, Meyer, & Evans, 1995), suggesting that the languages share the same neural circuitry. Furthermore, there is growing evidence for cross-language activation even when bilinguals are using just one of their languages when reading words (e.g., Schwartz, Kroll, & Diaz, 2007; Thierry & Wu, 2007) or sentences (e.g., Libben & Titone, 2009), when hearing words (e.g., Marian & Spivey, 2003; Spivey & Marian, 1999), or while naming pictures (e.g., Costa, Caramazza, & Sebastian-Galles, 2000), even when both languages use different written scripts (e.g., Hoshino & Kroll, 2008). In contrast, claims have been made for language independence in monolingual contexts given the strong inhibition of one language (Rodriguez-Fornells, Rotte, Heinze, Nösselt, & Münte, 2002).

The present study investigates whether cross-language activation is present in hearing bimodal bilinguals by asking whether there is activation of their second language (L2), Spanish Sign Language, LSE (*lengua de signos española*), when performing a task in their first language (L1), spoken Spanish. Thus, we will be testing cross-language and *cross-modal* activation, where modality refers to the perceptual channels employed by the language (oral-auditory and gestural-visual). To that end, we adapted the semantic relatedness paradigm used in a within modality setting by Thierry and Wu (2007; see also

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http://dx.doi.org/10.1016/j.jml.2015.11.005
0749-596X/

Wu & Thierry, 2010), who showed that bilinguals in two spoken languages activated their L1 (Chinese) while dealing with their L2 (English).

A very small number of studies focusing on bimodal bilingualism in deaf individuals have examined whether non-selective access can also be found across languages that do not overlap in modality. The activation of L1 when dealing with L2 occurs in deaf balanced bilinguals (Morford, Wilkinson, Villwock, Piñar, & Kroll, 2011). Deaf native signers of American Sign Language (ASL) read pairs of words in English and judged their semantic relatedness. The results showed cross-language activation since the presence of a phonological relation between the ASL equivalents of the English words influenced the reaction times for the semantic judgement. Thus, on one hand, in the context of a semantic relation, a (unseen L1) phonological relation produced a facilitation effect. Conversely, when the items were not semantically related, the (unseen L1) phonological relation gave rise to an inhibitory effect. A similar experiment was run in a subsequent study with two groups of unbalanced ASL/English bilinguals: a group of deaf ASL-dominant/English and a group of hearing English-dominant/ASL signers (Morford, Kroll, Piñar, & Wilkinson, 2014). Deaf bilinguals showed the same inhibitory and facilitatory effects reported previously. However, the hearing English-dominant signers, for whom ASL was their L2, showed only the inhibitory effect. Importantly, the deaf bilinguals were performing the task in their L2, while the hearing bilinguals performed the experiment in the written form of their L1. In addition, deaf native signers normally associate English word forms with ASL signs when they learn to read, while the hearing group would have linked the English orthography with the spoken English phonological forms. A very similar experiment using the same procedure was carried out in proficient deaf bilinguals in German Sign Language, DGS (*Deutsche Gebärdensprache*), and written German (Kubus, Villwock, Morford, & Rathmann, 2015). Kubus et al. (2015) found the inhibitory effect described by Morford et al. (2011) but not the facilitatory effect for the 'hidden' phonological relation (in the context of a semantic relationship). The authors linked this difference in the results to two reasons: differences in the experimental stimuli and in the languages involved.

Therefore, there is evidence for a cross-modal print-sign parallel activation when the languages are of a different modality in deaf and hearing bimodal bilinguals. However, there are two important considerations. Firstly, the spoken language was presented in its written form, a secondary code that provides a visual representation of an auditory signal. This involves looking for links between the representation of the static written form of the spoken language and the representation of the dynamic signal of the sign language. Additionally, this means that the explicit and the implicit codes are both visual, the experimental task is performed in the same (visual) modality as the language for which implicit activation is sought. Secondly, most of the participants in these studies were deaf bimodal bilinguals. These individuals are sign-print bilinguals due to their limited or indirect access to the acoustic form of the spoken language. More critically, these two factors interact since many deaf individuals learn to read by associating the signs of the signed language with the written forms of the spoken language. This raises the issue of the type of representation that deaf individuals have (of the written form) of the spoken language and how that may come to bear on the question of cross-linguistic and cross-modal activation.

In the present study we focus on the modality of the dynamic *primary* signal for a given language, namely, oral-auditory for spoken language, and visual-gestural for signed language. Examining these effects in hearing bimodal bilinguals, who acquire the dynamic primary signal of each language directly, would provide a clearer picture of cross-modal and cross-language activation. To our best knowledge, there are only two studies (Giezen, Blumenfeld, Shook, Marian, & Emmorey, 2015; Shook & Marian, 2012) that have looked directly at cross-language activation in hearing bimodal bilinguals with spoken language as stimuli using a very different procedure: the visual world paradigm. Participants heard a word and had to select one of four images on a screen. In addition to the target, there were two unrelated distractors and a phonological competitor of the target in the 'hidden' language (ASL) that shared three phonological parameters. Bimodal bilinguals looked more often and longer at the competitor rather than the distractors. Consequently, co-activation does not seem to be dependent on the modality of the languages in bimodal bilinguals. Thus, these two studies showed parallel activation of the sign language (the non-explicit language: ASL) during comprehension of spoken English in highly proficient hearing bimodal bilinguals. However, the participants were looking at images while hearing words, so the task offered visual stimuli in order to activate the signed language. In addition, the paradigm prompted explicitly a representation through the picture that activated the sign language competitor. Both the explicit trigger and the hidden target shared the visual modality. Furthermore, these stimuli were not controlled for iconicity of the signs. The form of iconic signs bears some resemblance to the meaning and iconicity has been found to play a role in the activation of signs from word stimuli in deaf bilingual children (Ormel, Hermans, Knoors, & Verhoeven, 2012). Thus, some of the picture stimuli from the experiment may have resembled the corresponding sign forms and have triggered the activation of signs. A task without any visual cues would be a stronger test to find out whether the cross-language activation is actually set off by the language input. Finally, none of these studies investigated whether these putative effects are modulated by age of acquisition (AoA); that is, whether the effect is present both in native bimodal bilinguals and late learners of the signed language.

When the signed language has been learnt impacts how the mental lexicon is organized, how the sublexical parameters are processed (Carreiras, Gutiérrez-Sigut, Baquero, & Corina, 2008; Corina & Hildebrandt, 2002; Emmorey & Corina, 1990; Emmorey, Corina, & Bellugi, 1995; Mayberry & Eichen, 1991) and it might also impact on the link with the spoken language. Hearing native bimodal bilinguals normally have deaf parents who use the signed language. The milestones of language learning in these