Original Article

second language research

Second Language Research
1–14

DOI: 10.1177/0267658317744009
journals.sagepub.com/home/slr
SAGE

The iconicity advantage in sign production: The case of bimodal bilinguals

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Abstract

Recent evidence demonstrates that pictures corresponding to iconic signs are named faster than pictures corresponding to non-iconic signs. The present study investigates the locus of the iconicity advantage in hearing bimodal bilinguals. A naming experiment with iconic and non-iconic pictures in Italian Sign Language (LIS) was conducted. Bimodal bilinguals named the pictures either using a noun construction that involved the production of the sign corresponding to the picture or using a marked demonstrative pronoun construction replacing the picture sign. In this last condition, the pictures were colored and participants were instructed to name the pronoun together with the color. The iconicity advantage was reliable in the noun utterance but not in the marked demonstrative pronoun utterance. In a third condition, the colored pictures were presented as distractor stimuli and participants required to name the color. In this last condition, distractor pictures with iconic signs elicited faster naming latencies than non-iconic signs. The results suggest that the advantage of iconic signs in production arises at the level of semantic-to-phonological links. In addition, we conclude that bimodal bilinguals and native signers do not differ in terms of the activation flow within the sign production system.

Keywords

distractor picture, iconicity, language production, picture naming, pronoun production, sign language, sign production

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1 Introduction

Most of the words in spoken languages bear an arbitrary relationship with the meaning they refer to. Apart from the unique exception of onomatopoeia, it is impossible to access the meaning of a word solely on the basis of its phonological shape. This conclusion, however, does not apply to languages that are based on vision and hand-effector systems for communication. In sign languages a large number of signs can resemble, to some extent, some aspects of the concepts they refer to. For instance, in American Sign language (ASL) the sign for circle is done by circling the index finger, which recalls the visual form of circles, while the sign for hammer resembles the way hammers are used (http://www.spreadthesign.com).

Iconicity denotes the resemblance-based mapping between the form of a lexical unit and its meaning. With respect to spoken languages, in sign languages there are far more opportunities for embodying in the sign perceptual or action-related aspects of the concepts (e.g. Dingemanse et al., 2015; Emmorey, 2014). This peculiarity of sign languages has drawn the attention of researchers interested in language processing, with some studies pointing out, for instance, that iconicity is a critical variable during vocabulary learning and language comprehension (for a recent discussion, see Perniss and Vigliocco, 2014). Here we focus on sign production. Below we review the empirical evidence concerning the role of iconicity in sign production.

In a study with native signers of British Sign Language (BSL), Vinson and colleagues (2015) reported that objects with iconic signs are named faster than objects with non-iconic signs. This observation has been recently replicated with a group of native signers of Italian Sign Language (*Lingua dei Segni Italiana*, LIS) (Navarrete et al., 2017). This study also included a control group of Italian native speakers performing the task in (spoken) Italian. The iconic advantage observed in LIS was absent in Italian, suggesting that the nature of the phenomenon relies on specific aspects of sign language. Importantly for our purposes here, the role of iconicity in sign production has also been found with proficient bimodal bilinguals, that is, hearing speakers who acquired sign language as a second language. Recently, Baus and Costa (2015) conducted an electrophysiological study with this population. They used pictures whose corresponding signs differed in terms of both iconicity and lexical frequency. Bimodal bilinguals named iconic signs faster than non-iconic signs, replicating the iconic advantage observed with native signers. In addition, high-frequency signs were named faster than low-frequency signs, also congruent with what observed with native signers (Navarrete et al., 2015). The event related potential (ERP) results showed more positive amplitudes for iconic signs with respect to non-iconic signs at a very early processing, exactly between 70–140 ms after picture presentation (i.e. in the P100 component). Interestingly, no frequency effects were reported within this time window, so that ERP fluctuations elicited by high frequency pictures were not different from those elicited by low frequency pictures. Baus and Costa concluded that 'the early ERP iconicity effect might result from semantic features of iconic signs being more strongly activated (or automatically) that those of non-iconic signs' (p. 48).

The study of Baus and Costa has relevant implications for the characterization of the iconicity advantage in sign production. The semantic (early) localization of the phenomenon, together with the widely accepted assumption that semantic representations are shared across the two languages of bilingual individuals, would imply that any 'semantic' phenomenon reliable in one language (e.g. sign language) should show up in the other language (e.g. spoken language) too. Contrary to this prediction, however, the early ERP iconicity effect was absent when the same group of bimodal bilinguals performed the task in their dominant spoken language (Catalan or Spanish). Although, as noted by Baus and Costa, this would suggest that iconicity and conceptual interaction is exclusive to sign modality, they do not specify how such exclusive interaction may act. The main aim of the current study is to shed light on this issue, investigating the ways in which this interaction happens.

1 On the locus of the iconicity advantage in sign production

Several chronometric effects observed in spoken picture naming tasks are interpreted assuming weight changes in the connections between semantic and linguistic representations (see, for instance, Damian and Als, 2005; Oppenheim et al., 2010). Here we propose a similar approach in order to account for the iconicity advantage. We hypothesize that iconicity modulates naming latencies by strengthening the links between semantic concepts and sign phonological forms (e.g. Navarrete et al., 2017; Thompson et al., 2009, 2010; Vinson et al., 2015). This would result in faster phonological information retrieval and, therefore, in faster naming latencies for pictures that refer to iconic signs with respect to non-iconic signs. A critical consequence of the previous hypothesis is that the iconicity advantage should emerge only when the semantic-to-phonological links are engaged in the task at stake. The first empirical aim of the experiment presented here was to test this prediction using a task in which iconic and non-iconic target objects are signed without the need of retrieving their corresponding signs, i.e. bypassing the specific semantic-to-phonology mapping system. This was achieved using a pronominal production task (see below).

Evidence congruent with the hypothesis that the iconicity advantage arises as a consequence of different weights in the mappings from concepts to phonology comes from a recent picture-picture study in which deaf signers named target pictures while ignoring superimposed distractor pictures. Using this task, target pictures are named faster when presented with iconic distractors than when presented with non-iconic distractors (Navarrete et al., 2017, Experiment 2). This reduced interference of the iconic distractors has been interpreted as reflecting faster/greater activation of these distractors with respect to non-iconic distractors. This in turn leads to a faster exclusion of the iconic distractor as a possible response and, consequently, to faster target naming responses. In the present study, we were interested in investigating whether a similar effect of distractor's iconicity can be observed in the case of bimodal bilinguals. This was the second empirical aim of the current research.

2 The present study

We adopted the double-naming procedure developed by Navarrete and Costa (2009a) to sign pronoun production but without distractor-words. Pronouns are lexical forms that substitute a previously mentioned syntactic entity. In LIS, the sign glossed PE

Figure 1. Illustration of the sign PE.

is an anaphoric demonstrative that invokes the notion of a person or object previously mentioned with the aim of obtaining greater clarity and effectiveness (Branchini, 2014). The production of PE as a demonstrative entails spatial agreement with the referent noun, so that the pronominal form is signed in the location where the referent noun has been previously signed (for an illustration of the sign PE, see Figure 1).

Participants in the experiment described below were bimodal bilinguals. They were presented with two black and white objects depicted side by side and they were instructed to name both objects, starting with the object located on the left (e.g. ‘knife’, ‘ball’). The preamble display serves as context in order to introduce the two possible antecedents of the subsequent target pronominal form. In addition, the preamble display allows us to test whether the experimental settings and materials were sensitive to iconicity effects. To this end, we ensured that the pair of objects in the preamble scenes were both iconic or non-iconic. In this object naming task we expected to replicate the iconicity advantage reported by Baus and Costa (2015). Once the participants named the two objects, the target display containing one of the two objects colored in red, blue, green or brown was presented at the center of the screen. Objects were colored with four different colors in order to avoid repetition of the same single response (i.e. PE). This also increased the uncertainty in the response and consequently the chance of observing differences in the naming latencies between the two iconic conditions. One group of participants named the second display using the demonstrative pronominal construction ‘*pe* + color’. In other words, participants signed the target picture pointing to the left or to the right depending on the location occupied by the target picture in the preamble display. Under the assumption that the advantage for iconic signs mostly relies on stronger semantic-to-phonological connections between the object concept and its corresponding phonological form, such an advantage should be reduced or cancelled out when iconic objects are named through marked pronominal utterances.

Important for our second empirical aim, in LIS the sign PE can also be used as an indefinite pronoun. In this case, PE is signed without any agreement with the object. We asked a second group of bimodal bilinguals to use an indefinite PE construction to name the same iconic and non-iconic colored objects. In this experimental condition the target object was a task-irrelevant stimulus as participants had to name the color of the depicted object without referring to the object itself (i.e. without referring to the previous location of the object). Participants uttered the construction '*pe* + color' pointing to the center of the screen. We expected to replicate the iconicity effect for distractor pictures reported by Navarrete and colleagues (2017), with faster naming latencies with iconic than with non-iconic distractor objects. The iconicity effect for distractor picture was explored under the assumption that iconic and non-iconic signs diverge in terms of cascade processing from semantics to phonology. Note that other studies have reported iconicity effects that are interpreted as reflecting cascade processing in the reverse direction, that is, from phonology to semantics. For example, Thompson and colleagues (2010) used a phonological decision task (i.e. deciding whether the sign involves straight or curved fingers), and found slower response times for iconic than non-iconic signs. This effect has been explained assuming that the more transparent form-to-meaning mappings for iconic signs would turn in automatic activation of meaning properties; this would lead to an interference because it provides information irrelevant to the phonological decision task (for further empirical evidence and related discussion, see the study by Baus et al., 2013 on forward and backward translation).

Finally, we add a control group of hearing Italian native speakers with no knowledge of LIS who performed the task in Italian. In this control group, participants name the second display using the demonstrative Italian form *Questo/a* (this $_{\text{masc/fem}}$) and the color of the object (e.g. *Questo è verde*, This $_{\text{masc}}$ is green). No iconic effects in either the preamble or the target displays for the control group were expected.

II Experiment

1 Method

a Participants. Participants were 20 hearing Italian-LIS bilinguals (mean age = 28.5; range: 21–49; SD = 8.1; 2 men) who learned LIS in adulthood. All of them have taken formal LIS lessons in the University for at least 2 years. The mean years of exposure to was 7 (range = 2–22; SD = 5.8) and the age of first contact to LIS was 21.4 (range = 19–39, SD = 4.9). Participants can be thus considered as not balanced bilinguals and more proficient in Italian than in LIS. Half of the participants signed PE as demonstrative and the other half as indefinite (both groups were matched by age and years of exposure to LIS, $p > .6$). In addition, 10 hearing native Italian speakers with no knowledge of LIS (mean age = 26.6; range: 21–47; SD = 7.5; 2 men) were recruited for the control group. All participants were right-handed, without a history of neurological or motor deficits, and had normal or corrected-to-normal vision.

b Materials. Forty-eight pictures of common objects were selected from different standard databases (e.g. Alario and Ferrand, 1999; Bonin et al., 2003): 24 pictures with iconic signs and 24 with non-iconic signs (see Appendix 1). Sign iconicity was based on iconic ratings obtained from a new group of 10 hearing Italian-LIS bimodal bilinguals, with the same characteristics as the experimental group, that did not take part in the main experiment. Raters were presented with a videoed sign and then with its corresponding object, and were required to indicate to what extent the sign reproduced 'visual characteristics of the object or aspects of action associated with the object' using a 7-point scale (1 for 'completely different', 7 for 'very similar'). Seventy signs were rated using this procedure. The group of iconic signs received higher iconicity ratings (mean = 6.29; SD = 0.44; range = 5.3–6.9) than the group of non-iconic signs (mean = 2.81; SD = 0.77; range = 1.7–4.4), $t(22) = 17.6$, $p < .001$. Given that lexical frequency measures for LIS are not available, we matched iconic and non-iconic signs in terms of written Italian Frequency using the *Corpus e Lessico di Frequenza dell'Italiano Scritto* (Bertinetto et al., 1995). This choice is motivated by the fact that previous research has shown that Italian written frequency predicts sign production in LIS (Navarrete et al., 2015) and that it is highly correlated with subjective frequency ratings (Navarrete et al., 2017).

Pictures were depicted in black, red, blue, green and brown lines. The black version of the pictures was used in the preamble scenes and the colored versions in the target scenes. Experimental trials were composed of two displays/scenes (i.e. preamble and target). In the preamble scenes two pictures were presented side by side (one on the left and one on the right side of the screen). Each single picture was presented eight times in preamble scenes, four times located on the left and four times on the right, and each time with a different picture of the same iconic group. Half of the times (i.e. 4) the picture was the target on the subsequent target display (two times when the picture was located on the left and two on the right side of the preamble scene). In total, each picture was presented four times as target for the '*pe + color*' utterance, each one with a different colored version. In total, there were 192 trials (48 pictures x 4 colored versions), and each picture appeared a total of 12 times (8 in preamble scenes and 4 in target scenes).

c Design and procedure. The hundred and ninety-two trials were randomly inserted into a sequence with the following constraints: a) the same picture was presented in the target display separated by at least 3 trials; and b), no more than three consecutive trials with the same colored target were presented. There was a short pause after 48 trials. Each participant was exposed to a different experimental sequence. An experimental trial for the bimodal bilingual participants involved the following events. At the center of the screen a fixation point was presented. Participants were instructed to press the keys 'z' and 'm' on the keyboard with the index fingers of their left and right hands respectively. As soon as the two keys were pressed, a screen was presented for 1,000 ms. This screen contained two fixations points occupying the locations where the pictures would be presented in the preamble. Once this screen disappeared, the preamble scene containing the two pictures was presented until one of the two keys was released from the keyboard. After the response to the two objects, participants pressed the 'z' and 'm' keys again and a new screen with one fixation point at the center was presented for 1,000 ms. Finally, the target display containing the colored object was presented at the center of the screen. The target display remained until one of the two key was released. After an inter-trial interval of 2,000 ms the next trial initiated (see Figure 2).

Participants were asked to sign the preamble and target scenes as fast and accurately as possible. Stimulus presentation and response times recordings were controlled by E-Prime 2 (Psychology Software Tools, Inc., Sharpsburg, PA). Before the experiment, participants were presented with the pictures and were instructed to sign them. They

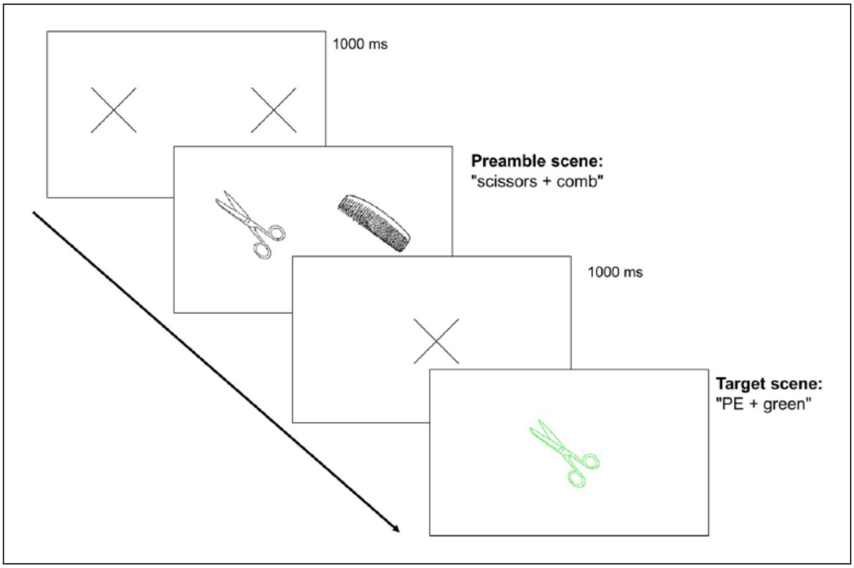

Figure 2. Example of an experimental trial.

were corrected if an inappropriate sign was used. Before the start of the experiment, participants were trained in the procedure. Four new pictures were selected for this training phase and presented three times, for a total of 12 training trials. A similar procedure was adopted for the spoken version with the difference that the inter-trial interval between the preamble and target display was fixed to 2,000 ms, that a new trial began after participants pressed the spacebar, and that participants responded to a headset microphone.

d Analyses. Analyses were performed separately for preamble and target scenes. Reaction times (RTs) were measured from the onset of the preamble and target displays, until the first key release in the bimodal bilingual groups and until speech onset in the Italian group. Three types of responses were scored as errors and excluded from the analyses of response latencies: a) production of clearly erroneous signs/nouns; b) production of disfluencies, utterance repairs or hesitations; and c) response times less than 250 ms or greater than 2,500 ms. RTs of correct responses were analyzed via linear mixed effects regressions (LMM) and error rates with generalized linear mixed models (GLMM) using the package "lme4" (Bates et al., 2015). In the models we set random intercept effects for participants and preamble scene. As categorical predictors we included Iconicity (Iconic, Non-iconic) and Type of utterance (Demonstrative pronoun, Indefinite pronoun). The interaction between these two predictors was also tested. Analyses were performed using the package "lme4" (Bates et al., 2015) with the R statistical software (R Core Team, 2016). As the distributions of the data for both the preamble and target scenes were not normally distributed, we used the Box-Cox text (Box and Cox, 1964) in R to estimate the most appropriate transformation for the data to reduce skewedness and approximate a normal distribution. Analyses were performed on transformed data.

Table 1. PE demonstrative utterance vs. PE indefinite utterance: Bimodal bilinguals.

	PE demonstrative utterance						PE indefinite utterance					
	Preamble scene			Target scene			Preamble scene			Target scene		
Condition	RT	SD	E	RT	SD	E	RT	SD	E	RT	SD	E
Iconic	1,225	372	5.1	955	261	8.6	1,134	312	5.1	716	145	3.9
Non-iconic	1,257	387	6.4	939	248	8.5	1,170	287	7.2	746	152	3.9
Mean	1,241		5.7	947		8.5	1,152		6.1	731		3.9
Iconic advantage	–32*		–1.3	16		0.1	–36*		–2.1	–30*		0

Notes. E = error rate; RT = reaction time (in ms); SD = standard deviation.

2 Results

a LIS: Preamble display. Naming latencies (RTs) were faster in the iconic condition (1,179 ms) than in the non-iconic condition (1,213 ms), B = 0.004, $t = 3.47$, $p < .001$. Critically, the effect of Type of utterance and its interaction with Iconicity were not significant, $p = .5$ and $p = .1$, respectively, indicating that the two groups were similar in overall naming latencies, and more importantly, in the magnitude of the iconicity advantage observed to name objects in the preamble scene. Furthermore, we performed the likelihood ratio test taking into consideration the Bayesian information criterion (BIC; Schwarz, 1978). We first estimated the difference (ΔBIC) between the model with the Condition predictor and the null model without predictors. Then, the Bayes factor (BF) approximation was calculated using the formula exp(ΔBIC/2) (Raftery, 1995). The BF approximation was 6.03, indicating that the model including the Condition predictor was six times more likely that the null model. The analysis of the error rates reported only a significant effect of Iconicity, B = −0.31, $t = -2.11$, $p = .03$. Error rates parallel the iconic advantage reported in the naming latencies, with iconic pictures eliciting more accurate responses. The effects of Type of utterance and the interaction with Iconicity were not significant, $p = .9$ and $p = .6$, respectively (see Table 1).

b LIS: Target display. The critical interaction between Iconicity and Type of utterance was significant, B = 0.011, $t = 3.112$, $p < .002$. As can be seen in Table 1, target displays containing iconic pictures were signed faster (716 ms) than displays with non-iconic pictures (746 ms) in the group of participants that uttered the indefinite pronoun, B = 0.008, $t = 3.15$, $p < .01$. The BF approximation was 2.4, indicating the model including the Condition predictor was two times more likely that the null model. For the pronominal group, the difference in RTs between iconic and non-iconic signs was not significant, $p = .4$. In the analysis of the error rates, there was a significant effect of Type of utterance, B = −0.89, $t = 2.35$, $p = .01$, with more accurate responses in the indefinite group than in the pronominal group. The effect of Iconicity, and the interaction between the two predictors were not significant (both *p*s = .9).

c Italian group. We explored the effect of Iconicity in preamble and target scenes separately. No significant effects of Iconicity were reported in either of the scenes, preamble

Table 2. Preamble scene vs. Target scene: Italian group.

Condition	Preamble scene			Target scene		
	RT	SD	E	RT	SD	E
Iconic	880	209	5.7	757	177	6.5
Non-iconic	871	187	6.9	750	172	4.8
Mean	875		6.3	753		5.6
Iconic advantage	9		−1.2	7		1.7

Notes. E = error rate; RT = reaction time (in ms); SD = standard deviation.

and target, *p*s > .3. The same pattern was reported in the error rates analyses, *p*s > 2 (see Table 2).

III General discussion

In this research we investigated the iconicity advantage in bimodal bilingual sign production. Several results have been obtained. First, in the preamble scenes, when the objects were signed through the production of a noun, pairs of iconic objects were named faster than pairs of non-iconic objects. This result replicates previous observations with bimodal bilinguals (Baus and Costa, 2015) and native signers (Navarrete et al., 2017; Vinson, et al., 2015). Second, when participants signed the pictures through a demonstrative marked pronominal construction, there was no trace of the iconicity advantage, so that naming latencies to iconic and non-iconic signs did not differ. Third, when the picture became a task-irrelevant stimulus and participants are required to sign the color instead of the object, we observed an iconicity effect, with faster color naming latencies with iconic distractor pictures than with non-iconic distractor pictures. This result nicely replicated the pattern obtained by Navarrete and colleagues (2017) with native signers. Fourth and last, no significant difference between iconic and non-iconic pictures was reported in the Italian group, either in the preamble display, when Italian participants named the objects with a noun construction, nor in the target display, when the object has to be named using a demonstrative pronoun. The lack of effects in the Italian group ensures us that the significant iconicity effects observed in the bilingual groups were due to the specific properties of sign language.

The main aim of the current study was to test the hypothesis that the iconicity advantage in sign production (mainly) arises as a consequence of different weights in the connections between semantic concepts and phonological representations of iconic and non-iconic signs. From this hypothesis two predictions have been derived:

- the iconicity advantage should disappear when iconic and non-iconic pictures are named bypassing the semantic-to-phonology mappings; and
- iconic distractors should be excluded from the response set faster than non-iconic signs.

The results obtained confirm both these predictions.

The hypothesis that the iconicity advantage in sign production arises at the level of the semantics-to-phonology links is not incongruent with the early EEG effect reported by Baus and Costa (2015). The iconic advantage would initiate early in time (i.e. semantic/visual processing) but will be fully expressed only when phonological units have to be retrieved in order to produce the name of a specific object, as was the case in the noun naming task of Baus and Costa and in the double-noun naming task of the preamble scene reported here. Interestingly, Baus and Costa observed an interaction between iconicity and frequency, so that only low frequency signs showed an iconic effect on those time windows typically related to lexical processing (i.e. from 140 to 350 ms after picture presentation). Such an interaction would suggest that these two variables similarly affect naming latencies. Congruent with this observation, research in speech production has suggested the semantic-to-phonological mappings as the place where the frequency effect emerges (Almeida et al., 2007; Kittredge et al., 2008); here we identify the same origin for the iconicity effect in sign production (for a related discussion see also the interaction between iconicity and age-of-acquisition reported in the picture naming experiment by Vinson et al., 2015).

Under the assumption of cascade processing in sign production (Navarrete et al. 2017), one could argue that the phonological content of the colored object would be activated in both the demonstrative and the indefinite pronoun productions, and therefore, that the iconicity effect should be present in both utterances. In other words, even if the demonstrative condition did not require the production of the sign corresponding to the target object, its activation at the semantic level would automatically cascade into the phonological level. Why, then, did we not observe an iconic effect in the demonstrative condition? At least two reasons can explain the lack of an iconicity effect in this condition. First, some studies have shown that the activation flow within the speech production system can be modulated by syntactic constraints. For instance, in a tip-of-tongue (TOT) experiment, Abrams and Rodriguez (2005) provided three types of prime words when participants reported being in a TOT state. Primes could be phonological related words of the same syntactic class (e.g. *cancel*) as the target word (e.g. *canonize*), phonological related words from a different syntactic class (e.g. *candid*), or unrelated words (e.g. *hectic)*. The results showed that, in comparison to unrelated prime words, phonological related primes from a different syntactic class increased the number of target retrieval events, while phonological unrelated primes from the same syntactic class had no effect. Abrams and Rodriguez's findings suggest the existence of some kind of syntactic constraint that modulates the weights of the connections within the speech production system. In the same vein, we can hypothesize that specific syntactic processes involved in the demonstrative and the indefinite conditions could modulate the dynamics of the activation flow in each utterance, determining thus to which extent the phonological representation of the target object is activated (see also for a similar argument Dell et al., 2008). A second reason refers to the different number of lexical elements needed for each utterance. In both the demonstrative and indefinite conditions the form PE and the color sign must be retrieved. However, only in the demonstrative condition it is also necessary to retrieve (lexical) location information regarding the position of the target object in the preamble scene. Research on speech production has documented that the activation flow within the system depends on the total number of lexical elements that are retrieved during the naming task (e.g. Humphreys et al., 1995; for a discussion, see also, Navarrete and Costa, 2009b). In our experiment, the retrieval of the location information required in the demonstrative pronoun condition could delimitate the phonological activation of the sign associated to the picture.

The longer RTs and the larger number of errors in the demonstrative condition suggest also that this utterance is more difficult than the indefinite utterance. Critically, this increased difficulty might have reduce the probability to observe an iconicity effect.[1] In order to investigate this possibility, we performed a further analysis on z-score transformed RTs in the target display. RTs were transformed into within-participant z-scores to correct for differences in processing speed and variability across groups of participants and augment traditional analyses of raw responses (see for discussion Faust et al., 1999; Hutchison et al., 2008). Transformed reaction times were entered in 2x2 analyses of variance, modeling the interaction between the within-subject variable Iconicity and the between-subjects variable Type of utterance. The interaction was significant ($F1(1, 18) = 7.41$, $p = .01$, $\eta_p^2 = .29$; $F2(1, 46) = 7.87$, $p < .01$, $\eta_p^2 = .14$). Paired samples t-test revealed that the iconicity effect was significant for the indefinite pronominal condition ($t1(9) = -2.07$, $p = .02$; $t2(46) = -3.05$, $p < .01$, but not for the pronominal condition ($t1(9) = 1.01$, $p = .34$; $t2(46) = 1.01$, $p = .31$, confirming previous results.

The distractor iconic effect we reported here with low proficiency bilinguals (i.e. non-native bimodal bilinguals) replicates the effect reported with native (high proficient) signers (Navarrete et al., 2017). This parallelism of iconic results between high and low proficient signers would suggest that proficiency does not limit the activation flows in the sign production system. Such a conclusion may have implications for the understanding of the role of language proficiency in cascade processing in bimodal bilingualism, as for instance the current debate regarding cross-language activation and sign language proficiency (Kubus et al., 2015; Morford et al., 2011; 2014; Villameriel et al., 2016) or the polarity of iconicity effects on translation tasks as a function of proficiency (Baus et al., 2013).

To conclude, our results demonstrate that iconicity is a critical psycholinguistic variable in bimodal bilingual sign production. One of the issues most explored by researchers interested in language production is the description of the mechanisms that allow us to link our thoughts to specific linguistic forms. To this respect, our results show also that second language signers walk this road like native signers.

Acknowledgements

We thank Anastasia Parini and Elias Ghetti for their help in data collection.

Declaration of Conflicting Interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

Note

1. We thank an anonymous reviewer for pointed us this alternative interpretation.

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Appendix 1

Experimental materials

- Iconic pictures: *ago* (needle), *anello* (ring), *auto* (car), *bicchiere* (glass), *caffè* (coffee), *cappello* (hat), *casco* (helmet), *chiave* (key), *croce* (cross), *forbice* (scissors), *gelato* (ice cream), *guanti* (gloves), *manette* (handcuffs), *moto* (motorcycle), *occhiali* (glasses), *pala* (shovel), *penna* (pen), *pettine* (comb), *piramide* (pyramid), *ragno* (spider), *scala* (ladder), *sigaretta* (cigarette), *siringa* (syringe), *spazzolino* (brush).

- Non-iconic pictures: *ananas* (pineapple), *antenna* (antenna), *arancia* (orange), *camicia* (shirt), *cane* (dog), *castello* (castle), *dottore* (doctor), *fabbrica* (factory), *fantasma* (gost), *finestra* (window), *fiore* (flower), *fragola* (strawberry), *luna* (moon), *mago* (magician), *osso* (bone), *panchina* (bench), *patata* (potato), *pera* (pear), *scoiattolo* (squirrel), *sedia* (chair), *sole* (sun), *specchio* (mirror), *statua* (statue), *uovo* (egg).