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Comparing child and adult development of a visual phonological system

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Research has documented systematic articulation differences in young children's first signs compared with the adult input. Explanations range from the implementation of phonological processes, cognitive limitations and motor immaturity. One way of disentangling these possible explanations is to investigate signing articulation in adults who do not know any sign language, but have mature cognitive and motor development. Some preliminary observations are provided on signing accuracy in a group of adults using a sign repetition methodology. Adults make the most errors with marked handshapes and produce movement and location errors akin to child signers. Secondly, there are both positive and negative influences of iconicity on sign repetition in adults. Possible reasons are discussed for these iconicity effects based on gesture.

Keywords: BSL, phonology, acquisition, handshape, iconicity

1. Introduction

One of the most important components of first language development involves the coupling of word forms with corresponding meanings. Linking phonology and semantics is a requirement also if the child is exposed to a signed language. Phonological development is well understood in children learning spoken languages (Vihman 1996) and also in spoken second language learning in adults (James 1996). In comparison we only have a partial picture of how children acquire signed languages (Morgan & Woll 2002) and only a handful of studies of hearing adults learning a signed language (Newell et al. 1983; Rosen 2004). Children learning to sign have to acquire the categories of handshapes, movements and locations pertinent to their particular signed language and this learning is constrained by a set of factors stemming from the visual modality and the child's developing linguistic, motor and perceptual systems (Mann et al. 2010). Because adults begin

Language, Interaction and Acquisition 1:1 (2010), **67–81**. DOI 10.1075/lia.1.1.05ort
ISSN 1879–7865 / E-ISSN 1879–7873

with mature motor and perceptual systems it is not clear what developmental patterns are at play with their articulation of a signed language. There has been a long debate in the literature as to whether the iconic elements of sign languages make learning simpler for young children (Newport & Meier 1990). While iconicity appears not to affect early L1 development it is possible that adult learners of sign language might treat iconicity differently because of their greater world knowledge (Campbell et al. 1992).

2. Acquisition by eye

Children exposed to sign languages from their deaf parents go through consistent and familiar stages of development (Newport & Meier 1985; Morgan & Woll 2002). Several studies of children's first signs report systematic child phonological errors in how signs are articulated compared with the adult input (Boyes-Braem 1990; Meier 2005; Morgan et al. 2007). The three main phonological components of a sign we discuss here are handshape, movement and place of articulation or location.

2.1 Acquisition of form

Sutton-Spence & Woll (1999) write for BSL that four handshapes are extremely common: "5" (spread hand), "A" (fist), "G" (index finger point), and "B" (flat hand). This small group of handshapes is used in 50% of the BSL lexicon, is maximally perceptually salient and has the simplest motoric articulation. For these reasons this set is referred to as *unmarked*. Several previous studies on different sign languages have documented unmarked handshapes as being the first ones used by young children (Boyes-Braem 1990; Meier 2005; Morgan et al. 2007). This pattern is said to be driven by both their perceptual and motoric simplicity.

The location parameter specifies where the hand is located in space in relation to the body (e.g., chest, nose, head or chin). Location is the most accurately articulated parameter by young children highlighting perceptual and motoric simplicity. In production young children often make errors in articulating signs with small specified locations, e.g. at the temple, preferring instead the more general location, e.g. head (e.g., Marentette & Mayberry 2000).

Lastly the movement parameter describes how the hand moves in the sign space (e.g., arc, circle or wiggling fingers). The developing motor system is implicated in sign language development with control of movements involving two axes of direction, for instance circular movement, being more difficult than movements involving one axis. Control of joints further from the torso, for instance the wrist, is also more difficult for small children. Young children's sign movements often show proximalisations whereby the whole arm or even torso moves rather than just the wrist (Meier 2005; Meier et al. 2008). Some signs e.g. FIRE[1] in BSL are composed of two types of movement: a path movement e.g. straight and simultaneously a hand-internal movement e.g. finger wiggle. These movement clusters are difficult for young children acquiring sign language and often one of the movements is omitted (e.g. Morgan, Barrett-Jones & Stoneham 2007).

2.2 Acquisition of meanings

Because many signs (unlike most words) make some direct visual link between form and meaning (e.g. the BSL sign EAT involves touching the hand to the mouth/chin area to indicate eating) it has been suggested that acquiring both the form and meaning of these signs might be easier for children than more arbitrary forms in spoken languages. But this hypothesis was largely rejected in several studies of ASL (Meier & Newport 1990; Meier et al. 2008). The debate about effects of iconicity has so far rested on the rate of development rather than on the details of particular sub-types of sign iconicity (although Meier, 1982, looked at the possible effects of two types of iconicity on the acquisition of verb agreement in ASL). Klima & Belugi (1979) rated signs for degrees of iconicity: (1) *Transparent signs* are the most evident ones and can be easily understood by signers and non-signers alike, for instance BSL EAT; (2) *Translucent signs* are signs which in context are self-evident e.g. BSL SCOTLAND (action of playing bagpipes); (3) *Obscure signs* which have a much more tenuous and unclear visual relationship to the referent, for instance BSL CHURCH (perhaps resembles pulling a chord to ring a bell) and (4) *Opaque signs* are arbitrary, for instance BSL SHOP or BSL NOT-YET.

2.3 Acquisition of signed languages by hearing adults

Adults learning a phonological system in a second language (L2) begin with already fully-formed phonological and semantic systems in their L1. Thus, learners make innovations to their phonological repertoire and semantic systems as well as creating new phonological categories (Flege 1995; James 1996). While this occurs within the same modality, it is not clear what influence a fully developed motor system will have on phonological parameter development in hearing adult learners of sign languages. Mirus et al. (2001) compared the imitation of ASL and DGS (German Sign Language) signs by signing naïve hearing American and German

1. English glosses are used for signs. All the signs in the paper can be accessed as videos at www.psychonomic.org/archive

adults and by fluent deaf signers of either ASL or DGS. They found similarities between movement errors observed in young sign learning infants and the adult sign learners. A study by Mann et al. (2010) reported similar errors in articulation of signs by hearing children who did not know any sign language as for significantly younger deaf signers. Thus, the same perceptual and motoric factors were involved in articulating signs in older hearing children. Second language learners have an established lexicon that can be used to learn new L2 words; however, hearing adults using a sign language are in a different situation given that the differences in modality do not allow direct phonological transfers of a phonological category in a spoken language to a signed language.

3. Summary

Language acquisition involves pairing forms and meanings together — a feat which in L1 development means that children must build a phonological and semantic system from scratch. This differs for L2 learners, as they at least in part may adjust already existing representations to match the new target language. There has been some research on signed language acquisition suggesting that children master both form and meaning in predictable ways with errors linked to immature motor, perceptual and language-specific mechanisms. Further, it appears young children's sign language acquisition is not motivated by the iconic aspects of signs but we know very little about this aspect in adult L2 development of sign. This paper presents preliminary data on hearing adults' accuracy in articulating signs and compares this with previous reports of young deaf children's L1 sign language acquisition. In particular we compare:

1. the articulation accuracy of the main formational parameters of signs;
2. the influence of iconicity on articulation accuracy.

4. Study 1

4.1 Participants

The child data were two case studies of deaf children of deaf parents: Mark and Gemma (Morgan et al. 2006; Morgan et al. 2007).

4.2 Methods

Mark was filmed in naturalistic interaction twice a month in the home from the ages of 22–36 months. Gemma was filmed once a month in natural interaction in the home between the ages of 19–24 months. Both children's signs were compared with their mothers' BSL input as the target. Data coding took place in two rounds: first all possible signs were identified; then they were coded with respect to the three main phonological parameters (handshape, location and movement). Trained coders watched the videos and transcribed each child sign using Brennan's adaptation of Stokoe notation (Brennan 1990). Intercoder reliability was between 90–100% for all signs. Signs that could not be distinguished on the videos were excluded from analysis.

4.3 Results (1): Articulation accuracy of the main formational parameters of signs

Gemma's signs were used for this first analysis. The sign parameters in her first signs: handshape, movement and location were produced with different levels of accuracy. Errors were observed with 41% of target handshapes, 45% of target movements and with 25% of target locations. Handshape accuracy was atypically good. Previous research on several sign languages has found errors to be over 50% for this age (e.g., Meier 2005).

We did not carry out an analysis of parameter accuracy in Mark's signing but we did track the development of particular handshapes. Unmarked handshapes were most commonly used especially in the earliest sessions but over time the repertoire gradually increased. Figure 1 shows specific ages when different handshapes entered Mark's signing.

As Mark' handshape repertoire grew the number of handshape substitutions decreased. See Table 1.

If the child produced a sign with a different handshape to that used in the adult input, we coded this as a substitution e.g. BSL COW signed with a B hand instead of a Y. We also noted where in space the substitutions occurred. When a handshape substitution occurred in Mark's signs, the proportion of handshape substitutions was lower when his hands were within central visual space ($M = 0.24$, SD = 0.063) than when his hands were out of his visual field ($M = 0.325$, SD = 0.107). A paired

Table 1. Proportion of Mark's signs (%) which contained a marked handshape substitution. The child used an unmarked handshape instead of the target.

Age (y;m)	**1;10**	**2;2**	**2;6**	**2;8**	**2;9**	**3;0**
Percentage substitutions	44	33	26	22	26	17

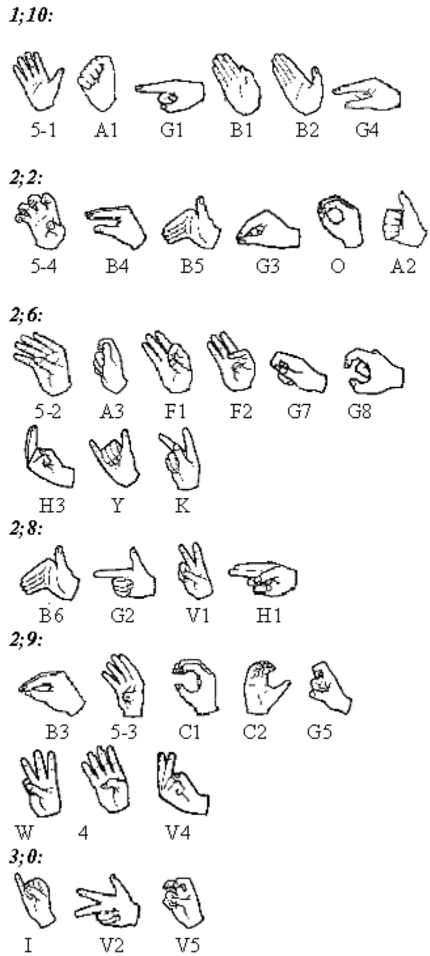

Figure 1. Use of different handshapes at different ages in the Mark corpus

samples *t*-test revealed a significant difference between these two sets of errors ($t(5) = -0.3.263$, $p = 0.011$). Figure 2 illustrates the difference between handshape substitutions in central and peripheral vision

For movement, Gemma's signs were produced with differing accuracy related to whether path was the sole movement in the target sign (46% errors) or was combined with hand internal movement in movement clusters (85% errors).

4.4 Results (2): Influence of iconicity on frequency of sign production

Mark's first signs across four time periods were separated into two groups: (1) Iconic: Transparent/Translucent and (2) Non Iconic: Obscure/Opaque. All the

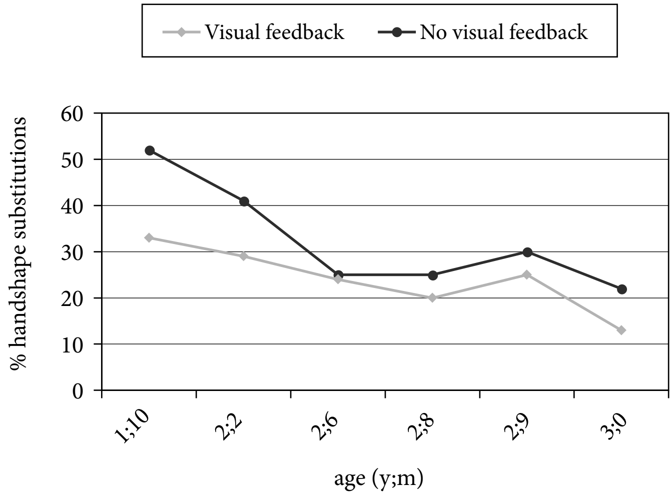

Figure 2. Proportion of Mark's signs with handshape substitutions where the location afforded visual feedback for the child and where the location did not afford feedback.

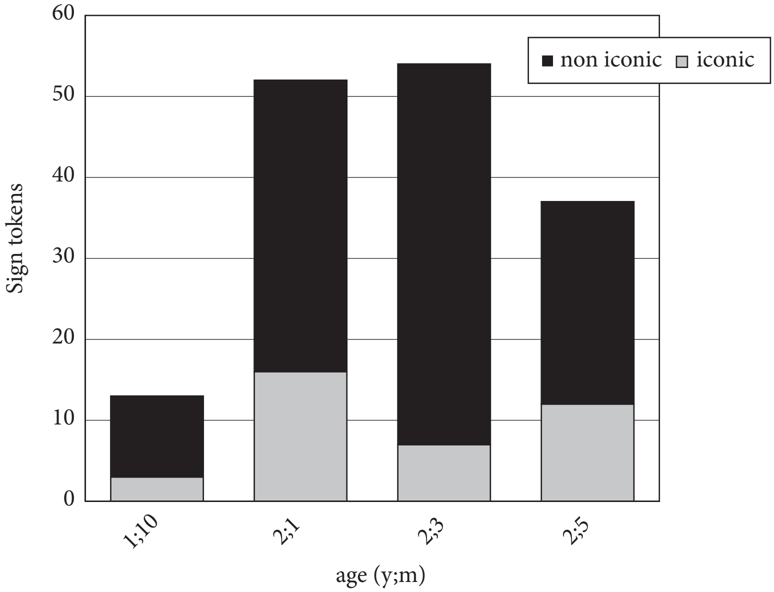

Figure 3. Total sign tokens produced by Mark at four time periods and their degree of iconicity

signs observed in the child's signing were re-signed on video by a deaf native signer. A group of deaf and hearing experts in the same research team grouped these signs into those with clear iconic motivation and those with no clear iconic motivation using the rationale outlined in Klima & Bellugi (1979). As can be seen in Figure 3, there were far more occurrences of non-iconic signs (e.g., BSL: MOTHER, SISTER, KITCHEN) than iconic (BSL: EAT, WALK, BALL) during this early period.

5. Study 2

5.1 Participants

The adult participants were five young adults (three female and two male, ages: 25–35 years). All of them were right-handed except for one who was ambidextrous. None had knowledge of any sign language.

5.2 Method

Videos of 27 single signs produced by a deaf native signer were shown to participants on a 17″ computer screen. Participants were instructed to wait till the signer stopped and then copy what they saw as accurately as possible. Signs came from Vinson et al. (2008).[2] Participants' sign reproductions were filmed and their accuracy of articulation analysed. All signs were coded for three phonological parameters: handshape, location and movement. The target stimuli were coded first and then participants' repetitions were coded according to those targets. Participants received 1 point if the phonological parameter was exactly the same as that of the target and a 0 if it was different (see Ortega, in prep. for more details).

5.3 Results (1): Articulation accuracy of the main formational parameters of signs

In the five adult participants there were more errors in the articulation of handshape, as previously found in the child signers. The proportion of errors was the highest in articulation of handshape ($M = 0.57$, SD = 0.36) followed by movement ($M = 0.34$, SD = 0.22) and location being the most accurately repeated ($M = 0.22$, SD = 0.34). We performed a repeated measures analysis of variance (ANOVA) with phonological parameter as the within-subject factor and we found that there was a significant difference [$F(1, 24) = 209.12$, $p = 0.000$]. Further paired sample t-tests revealed that there was a significant difference in accuracies between handshape and location [$t(24) = -3.75$, $p = 0.001$] and between handshape and movement

2. See appendices 1 for a list of the signs. All the signs can be accessed at ww.psychonomic.org/archive.

[$t(24) = -2.585$, $p = 0.016$] but no difference between location and movement [$t(24) = 1.069$, $p = 0.296$]. Thus, sign repetition was imperfect; even though the adults had mature motoric development, they were unused to signing. As with the child data described previously, we looked at the adults' repetition accuracy with unmarked or marked handshapes. From the 27 signs, 14 contained an unmarked handshape and 13 a marked handshape. The adult participants, in keeping with what we observed with the children, had a higher proportion of accurate unmarked handshapes ($M = 0.63$, $SD = 0.08$) than marked ($M = 0.23$, $SD = 0.15$). A paired samples t-test revealed a statistically significant difference between both types of handshapes [($t(4) = 4.73$, $p = 0.004$). Examples of movement errors from the adults included articulating a forward circular movement instead of a backward movement, a clockwise movement instead of an anti-clockwise one and path of movement substitutions, for example an arc or a circular movement was changed to a simpler straight path movement. An example of this last type of error is shown in Figure 4.

As previously reported for children (Meier 2005) and adults (Mirus et al. 2001), there were also examples of proximalisations, for instance, the BSL sign EMAIL involves a flicking of the index finger while the rest of the hand remains motionless. This sign was produced by the adult sign novices by a bending the whole wrist. The adult participants' signs were also coded for combination of movement components. Participants' articulations received a score of 1 if they performed exactly the same movement as the model and 0 if it was different. The signs were divided into three groups depending on whether they presented internal movement (43% errors), path movement (66% errors) or clusters of both internal and hand movements (84% errors). Thus combinations of path and hand internal movements were the most difficult movement type for both the adults as well as the two children reported in study 1. Further, as in the child data, the adults when attempting to repeat signs with movement clusters adults most often deleted

4a (target) 4b (error)

Figure 4. A movement error in the sign TO-WRITE where the target circular movement (4a) was performed with a straight path by the non-signer (4b).

one of either the path or internal movements. However adults found signs with only hand-internal movements easier to repeat than signs with only path movement while the opposite was the case for young children.

5.4 Results (2): Influence of iconicity on articulation accuracy

The same five participants watched a different set of 32 signs from the Vinson et al. (2008) study. Half of the signs were rated as highly iconic and the other half were rated with low iconicity by 33 deaf signers from throughout the UK (see Vinson et al. 2008). The two groups of signs were matched for phonological complexity. Unlike the previous experiment, each sign was shown along with its English translation. See Appendix 2 for a list of the signs. Participants copied signs as in the previous experiment and their sign reproductions were filmed. Participants' articulations were coded the same way as in the previous study: each phonological parameter (handshape, location and movement) was rated with 1 if the parameter matched the model and 0 if it did not. The summary of the data is presented in Table 2.

Table 2. Mean proportion of correct sign repetitions by the adults for each phonological parameter . Standard deviations appear in parenthesis.

	Iconic	Non-iconic
Handshape	0.43 (0.38)	0.44 (0.40)
Movement	0.7 (0.27)	0.64 (0.34)
Location	0.86 (0.21)	0.71 (0.34)

In both the iconic and non-iconic conditions, handshape is the parameter least accurately produced, followed by movement and location is again the most accurate. There is no difference between iconic and non iconic signs for articulation accuracy but location accuracy for iconic signs approaches significance.

6. Discussion

We carried out a qualitative comparison of data produced by young children in the first stages of sign language development to accuracy scores for adult's repetition of signs and found similar patterns: location is the most accurate parameter followed by movement and lastly handshape. Marked handshapes are used with most difficulty by children and adults. We also observed the same types of errors previously reported in child sign acquisition including marked handshape substitutions, omission of hand internal and path combinations (movement clusters) and proximalisation of location. This overlap between child and adult sign articulation patterns supports the role of phonetic complexity in sign language production in child and adults (Boyes-Braem 1990; Meier et al. 2008; Mann et al. 2010). The exact influence of motor, perceptual, linguistic or cognitive constraints is subject to further research. We found one difference between adult and child signers in the movement parameter. The adults produced hand internal movements with most accuracy (but not in movement clusters). This feature is produced with most difficulty in child signers. It may be the case that adults have more developed visual perception and fine motor skills to capture these small hand internal movements.

While marked handshapes were least accurately produced by the adults there were exceptions with the F1 and Y handshapes (see Figure 1). Both resemble gestural emblems for 'ok' and 'telephone' respectively. It is plausible that translucent iconic signs will be more accurately produced because they have overlapping features with gestures in both their form and meaning (Ortega in prep.).

Secondly, we looked at the role of iconicity on sign articulation in child signers and in adults doing sign repetition. We did not observe any preference for iconic signs in the child data (see also Meier et al. 2008; Tolar et al. 2007). In the adults there was also no difference in articulation accuracy between iconic and non-iconic signs. However, we did see some qualitative effects of iconicity in the adults' signing both in a positive (increasing the accuracy of the sign's articulation) and a negative direction (decreasing the accuracy of the sign's articulation). An example of iconicity improving accuracy was seen in the repetition of the BSL sign CASTLE where signers initially produced a flat horizontal movement, but as they observed that their own repetitions did not visually represent a castle, they self repaired and started to move the sign upwards. Examples of iconicity reducing accuracy were also observed, for instance, with the item shown in Figure (4). Adult signers adjusted the handshape for the BSL sign TO-WRITE to the way they hold and move a pen when they write in the real world. In other words, they departed from the exact phonological parameters of the stimuli to impose their own hand configuration based on real world experience. This is not something an infant is able to do as easily. Thus, for some iconic signs adult participants may have recognised the gestural origin of the sign and performed these gestural cognates with more articulatory freedom (like the gesture they resemble), and thus, adults lost accuracy compared with the target sign. This possibility is in keeping with the gestural advantage for some marked handshapes (Y in the gesture 'telephone' and F1 in the emblem 'ok') described previously.

Finally, we found that the parameter of location was more accurate in iconic signs (see Table 2) although this was not quite statistically significant. One explanation for this difference between parameters is related to the potentially higher amount of meaning carried in the iconicity of location (e.g. the head location normally expresses meanings of psychological states, signs on the torso express physical states, etc. — see Demey & van der Kooij 2008). If location carries more transparent meaning in signs and these meanings overlap with the gestural repertoire employed by the adults, this may represent a further site for transfer from gestures to signs in adults with mature world knowledge.

In conclusion, by comparing child and adult learners we can see how the effects of age of acquisition, practice and community can influence both the types of learner errors observed in sign articulation, as well as the recruitment of gestural forms by hearing people when attempting to use a sign language.

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Résumé

Les différences systématiques entre les caractéristiques articulatoires des premiers signes de l'enfant et celles de l'input ont fait l'objet de recherches antérieures. Les explications possibles pour ces différences s'appuient soit sur les propriétés du traitement phonologique, soit sur les limites des capacités cognitives de l'enfant, soit sur l'immaturité du développement moteur chez l'enfant. Un moyen pour départager ces différents facteurs potentiels est d'étudier l'articulation des signes chez des adultes qui ne connaissent pas la langue des signes parce qu'ils ont un développement moteur et cognitif mature. Nous proposons ici une étude préliminaire des compétences en langue des signes chez un groupe d'adultes lors d'une tâche de répétition. La plupart des erreurs des adultes concerne les configurations marquées et ils produisent les mêmes erreurs que les enfants signeurs pour les mouvements et les localisations. D'autre part, on observe des effets à la fois négatifs et positifs de l'iconicité sur la répétition des signes par les

adultes. Nous proposons une explication de ces effets de l'iconicité fondée sur l'utilisation de gestes par les adultes.

Appendix 1

Sign	Movement	Location	Handshape
DROP	Both	Signing space	unmarked
FIRE	Both	Signing space	marked
GO_OVER_ONES_HEAD	Both	Head	marked
GOSSIP	Both	Signing space	marked
HOLLAND	Both	Head	marked
JUGGLE	Both	Signing space	unmarked
SCARF	Both	Signing space	unmarked
SLEEP_YOUTH	Both	Face	unmarked
CASTLE	Both	Signing space	unmarked
EMAIL	Internal	Signing space	marked
FINALLY	Internal	Signing space	unmarked
FINISH	Internal	Signing space	marked
HOLIDAY	Internal	Signing space	marked
PILLOW	Internal	Head	unmarked
SHINE	Internal	Signing space	unmarked
SIGN_LANGUAGE	Internal	Signing space	unmarked
SLEEP	Internal	Face	marked
STOP	Internal	Signing space	marked
ARGUE	Path	Signing space	marked
BOMB	Path	Signing space	unmarked
DIE	Path	Signing space	marked
IT_WILL_DO	Path	Signing space	unmarked
HOSPITAL	Path	Signing space	unmarked
KANGAROO	Path	Signing space	unmarked
MALAYSIA	Path	Head	unmarked
SHOP	Path	Signing space	marked
SUBTITLES	Path	Signing space	marked

Appendix 2

Iconic signs are matched with a non-iconic sign in their level of phonological complexity.

Iconic signs			Non-iconic signs
AEROPLANE	Path	Marked	**EUROPE**
BELT	Path	Marked	**SHOP**
BINOCULARS	Internal	Marked	**WORRIED**
TROPHY	Path	Marked	**TEACH**
BUTTERFLY	Internal	Unmarked	**FOOTBALL**
CAMERA	Internal	Marked	**AMAZED**
CRY	Path	Unmarked	**CHURCH**
EAT	Path	Marked	**ASK**
FIRE	Both	Unmarked	**CASTLE**
ICE-CREAM	Path	Marked	**CONFIDENT**
INJECT	Both	Marked	**THANKS-FOR-NOTHING**
PUSH	Path	Unmarked	**WAIT**
SKI	Path	Unmarked	**NOT-YET**
TIE	Path	Marked	**CUT-DOWN-TO-SIZE**
WRITE	Path	Marked	**KITCHEN**
HAMMER	Path	Marked	**MORE**

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