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From Gesture to Sign Language: Conventionalization of Classifier Constructions by Adult Hearing Learners of British Sign Language

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Abstract

There has long been interest in why languages are shaped the way they are, and in the relationship between sign language and gesture. In sign languages, entity classifiers are handshapes that encode how objects move, how they are located relative to one another, and how multiple objects of the same type are distributed in space. Previous studies have shown that hearing adults who are asked to use only manual gestures to describe how objects move in space will use gestures that bear some similarities to classifiers. We investigated how accurately hearing adults, who had been learning British Sign Language (BSL) for 1–3 years, produce and comprehend classifiers in (static) locative and distributive constructions. In a production task, learners of BSL knew that they could use their hands to represent objects, but they had difficulty choosing the same, conventionalized, handshapes as native signers. They were, however, highly accurate at encoding location and orientation information. Learners therefore show the same pattern found in sign-naïve gesturers. In contrast, handshape, orientation, and location were comprehended with equal (high) accuracy, and testing a group of sign-naïve adults showed that they too were able to understand classifiers with higher than chance accuracy. We conclude that adult learners of BSL bring their visuo-spatial knowledge and gestural abilities to the tasks of understanding and producing constructions that contain entity classifiers. We speculate that investigating the time course of adult sign language acquisition might shed light on how gesture became (and, indeed, becomes) conventionalized during the genesis of sign languages.

Keywords: Gesture; Sign language; Visuo-spatial processing; Classifiers; Spatial expressions; L2 learners; Phonology; Morphology

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1. Introduction

There has long been interest in why languages are shaped the way they are. One perspective is that form-meaning mappings are, for the most part, arbitrary; that is, there is no reason why the word "dog" is made up of those sounds and not others (Saussure, 1974). However, this assumption has been robustly questioned, especially when looking at languages other than English, where words frequently pick out particular semantic features through their sound structure (e.g. Lyons, 1977; Simone, 1995; and a review of this debate in Perniss, Thompson, & Vigliocco, 2010).

Arbitrariness, while giving freedom for the expansion of the lexicon (Lyons, 1977), arguably makes learning such form-meaning mappings more challenging. Imagine an English-speaking adult who is learning French. She hears the sentence "il y a un verre sur le cahier," and knows "il y a" (there is), "un verre" (a glass), and "le cahier" (the notebook) but does not yet know the meaning of "sur." Without a supporting context (e.g., a picture), the spatial relationship between the glass and the notebook that is encoded by "sur" (on) is opaque. Her morphological and syntactic bootstrapping might narrow it down to a preposition, and she might already know some prepositions whose meanings she can eliminate from the meaning of "sur." She might also know that some spatial relationships are more plausible than others. But that is all. It is certainly inconceivable that she would be able to come up with the word "sur" herself to express this spatial relationship if she has not previously encountered it.

For the same adult learning British Sign Language (BSL), the spatial relationship is more transparent because the signed construction is iconic. Iconicity in signed languages can be defined as a visually motivated relationship between the form of the sign and the form of the referent (Frishberg, 1975; and a recent review of iconicity in speech and sign in Perniss et al., 2010). As illustrated in Fig. 1a, there is a certain degree of iconic

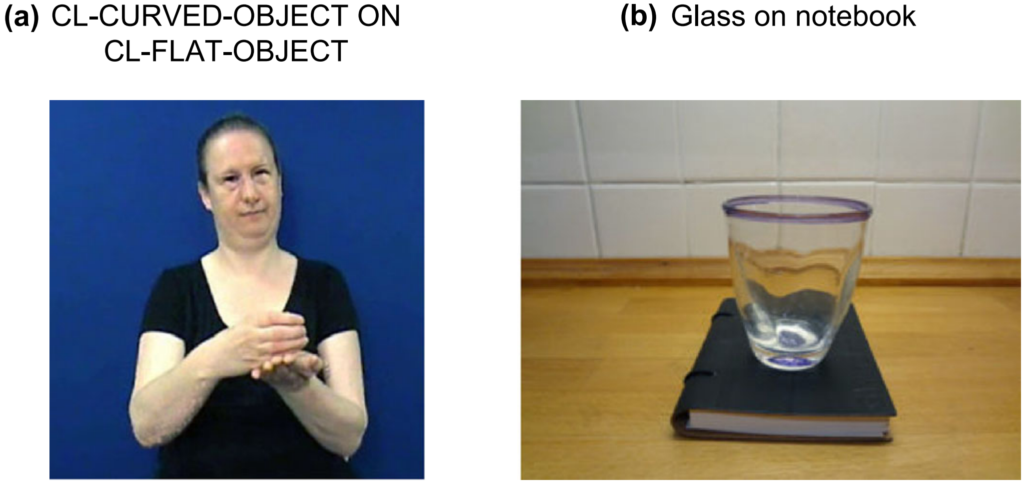

Fig. 1. (a) CL-curved-object on CL-flat-object. (b) Glass on notebook.

mapping in the configuration that the hands adopt, with a curved handshape representing the shape of the glass, and a broad flat handshape representing the surface of the notebook. Taub (2001) has termed this mapping "shape-to-shape" iconicity, and Perniss (2007) "imagistic" iconicity. Strikingly, the two hands map the real-world relationship between the referents shown in Fig. 1b, in what Emmorey terms "the confluence of language and space" (Emmorey, 1996, p. 171). One can, therefore, imagine that iconicity provides a way of "breaking into" sign language, and that spatial constructions such as that illustrated in Fig. 1a would be relatively straightforward for learners of BSL to understand, and even to create themselves.

The literature on how hearing adults learn signed languages is sparse and focuses on iconicity at the lexical level (Baus, Carreiras, & Emmorey, 2013; Campbell, Martin, & White, 1992; Lieberth & Gamble, 1991). Those studies demonstrate that iconicity supports adults in learning signed languages. The studies reported in this paper focus not on single signs but on spatial constructions.

In signed spatial constructions such as that shown in Fig. 1a, not only is the mapping between hands and objects iconic, but the signer is using her hands in a similar way to how the hands represent space in co-speech gesture (Casey, 2003; Kendon, 2004; Liddell, 2003). Previous studies have shown that hearing adults who are asked to use gestures, but no voice, to describe how objects move in space will take advantage of iconicity and use gestures with rudimentary similarities to signed languages (Schembri, Jones, & Burnham, 2005; Singleton, Goldin-Meadow, & McNeill, 1995). Before discussing in more detail what gesturers do, and the predictions we make for learners of a signed language, we first describe how signers represent the position and movement of objects in space.

The handshapes that signers use to represent different classes of objects are termed "entity classifiers" (or alternatively "semantic classifiers," Supalla, 1986; "whole entity classifiers," Zwitserlood, 2012). Entity classifiers can encode how objects move, how they are located relative to one another ("locatives;" Fig. 1a), and how multiple objects of the same type are distributed in space ("distributive plurals"). Whereas the formational components of signs, namely handshape, movement, orientation, and location (Brentari, 1998; Stokoe, 1960), are not necessarily individually meaningful in *lexical* signs (Johnston & Ferrara, 2012), these components *do* express meaning in classifier constructions. This is because in classifier constructions, each of these components has a morphological role (Supalla, 1986; Zwitserlood, 2012).

The handshapes in Fig. 1a have the meaning of "object from the class of curved entities" (in this particular case, "glass") and "object from the class of broad and flat entities" (i.e., "notebook"). The orientation of the hand shows that the glass is upright, rather than on its side or upside down. The location of the curved hand relative to the flat hand shows that the glass is on the notebook, and not in any other spatial relationship.

The production of entity classifiers involves selecting the correct handshape for the class of entities to which each referent belongs, and moving, orienting, and locating the hands correctly relative to one another. Conversely, comprehension involves interpreting which handshapes refer to which entities previously mentioned in discourse (Zwitserlood, 2012). Comprehension also involves interpreting how the hands' movement, orientation, and location relative to one another map onto the spatial relationship of these entities in the real world.

Do people with no knowledge of sign language produce entity classifier-type constructions when forced to describe motion events using just gesture? The available evidence suggests that they do, but not identically to signers. Singleton, Morford, and Goldin-Meadow (1993) and Schembri et al. (2005) both compared the description of motion events in deaf users of different sign languages and in the voice-off gestures (i.e., gestures without accompanying speech) of hearing people who knew no sign, and coded for accuracy across the different formational parameters. Both studies reported a large overlap in the way gesturers and signers expressed movement and location (~70%), but a much smaller overlap in the handshapes they used to represent objects (~25%). Specifically, gesturers actually used a greater number of different handshapes, including handshapes that were more iconic than those used by signers (although this was not always the case). These findings led Schembri et al. (2005) to claim that entity handshapes are conventionalized, whereas the expression of location and movement is not (for a description of conventionalization in sign languages, see Janzen, 2012), and they led Singleton et al. (1993) to claim that location and movement may be basic to communication on the hands.

In a more recent study, Brentari, Coppola, Mazzoni, and Goldin-Meadow (2012) investigated the handshape differences between signers and gesturers in more detail. They found not only that the groups used different handshapes when describing the location of stationary and moving objects in space but that signers' handshapes carried greater phonological complexity compared to those of gesturers. Again, Brentari et al. (2012) argued that this finding reflects the creation of a conventionalized system in signed languages.

Further evidence that handshape is conventionalized in signed languages comes from cross-linguistic differences in the handshapes that signers select to represent different classes of objects (Taub, 2001; Zeshan, 2003; Zwitserlood, 2012). For example, in Hong Kong Sign Language, the classifier handshape for AEROPLANE consists of the extended thumb, middle finger, and little finger, while in ASL the AEROPLANE classifier consists of an extended thumb, index finger, and little finger. In BSL, neither of those handshapes exists in the phonological inventory, and AEROPLANE is represented by the Y handshape (extended thumb and little finger). Languages also differ in how they carve up semantic space to classify entities. For example, ASL has a broad "object" class represented by the A upright handshape (fist with extended thumb), which can be used for an object as large as a building or as small as a vase on a shelf (Aronoff, Meir, Padden, & Sandler, 2003). There is no similar class of objects, represented by a single handshape, in BSL. The system of entity classifier handshapes, therefore, demonstrates a certain degree of arbitrariness and conventionalization that presumably has to be learned—the handshapes that hearing adult learners recruit from gesture might not be those used in the signed language they are learning.

In contrast to the growing numbers of studies of gesturers, we are not aware of any research that has investigated how adult learners of a signed language acquire a classifier system, and this is the motivation for the studies that we report in this paper. We investigated two types of classifier constructions where the referents are stationary, namely locatives (i.e., X IS AT Y), and distributive plurals. Specifically, we investigated whether hearing adults who are learning BSL, and who have, therefore, had some exposure to a conventionalized system of classifier handshapes, are able to select the same handshapes as deaf signers in these two types of entity classifier constructions.

We predicted that location will be more straightforward to learn, because learners have a gesture system that takes advantage of the direct mapping between the location of objects, and this might transfer to signed languages. Furthermore, the mapping of location is invariant cross-linguistically and is not conventionalized: No sign language has been reported where, for example, an "on" relationship between two objects is expressed by a "next to" relationship of the hands, or "below" by an "in front" of relationship. Location is, therefore, likely to be understood and expressed accurately by learners of BSL.

It is not clear how learners will fare with orientation, and orientation has not been reported in previous studies of gesturers. Brentari (2007) has argued that there are restrictions on the types of orientation relations that can be expressed by entity classifiers, which suggests that iconicity is constrained by the grammar, and that these conventions have to be learned. However, cross-linguistic differences in orientation appear not to have been reported. This suggests that the mapping between hand orientation and the orientation of objects in the real world might be relatively direct and unconventionalized, and consequently that orientation might be straightforward to learn. Therefore, we made no predictions with respect to orientation.

2. Study 1. Production in learners of BSL

Learners of BSL were asked to describe pictures, in BSL and without speech. The same pictures had been shown to elicit entity classifier constructions in native signers. Our aims were to investigate whether the different components of these entity classifiers were produced equally accurately, or whether the disadvantage for handshape that has been reported for non-signers in gesture would characterize their productions.

2.1. Methodology

2.1.1. Participants

Twelve hearing adults (two male), with a mean age of 28.6 years (*SD* = 5.8, range 22–44) participated. They had been learning BSL for between 1 and 3 years, taking classes no more frequently than once a week. All had taken examinations offered by Signature (formally the Council for the Advancement of Communication with Deaf People, http://www.signature.org.uk/). All had passed the most basic-level qualification, BSL Level 1 (beginner), eight had passed BSL Level 2 (intermediate), and three had started taking classes at pre-level 3, in preparation for being able to attend a level 3 (advanced) class. Five were working alongside Deaf colleagues and therefore were seeing BSL on a daily basis, but seven were not using BSL regularly, aside from attending classes and Deaf events (such as BSL theater and art gallery talks).

2.1.2. Procedure

Participants were shown two pictures in quick succession on a laptop screen. Each picture featured two or more objects, whose location or orientation, or both, had changed in the second picture. The first picture was presented for 3 s, and then the second for 3 s, after which participants saw a large question mark on the screen. This was the cue for them to explain in BSL what was different between the two pictures, that is, what had changed.

We tested two types of construction that involve entity classifiers: locatives, (i.e. X IS AT Y) and distributive plural forms. For locatives, there were three types of trials: (a) change of location; (b) change of orientation; and (c) change of both location and orientation (see Fig. 2), and there were 10 of each. There were also 10 distributive plural trials, where the distribution of objects changed (see Fig. 3), with half of those changing just location and half changing location plus orientation. Except for three locative constructions that described a single object, all other stimuli required two-handed classifier constructions.

2.1.3. Coding

Learners' productions were scored for accuracy in comparison to the productions of four adult native signers of BSL (three deaf and one hearing). When we asked the native signers to describe the pictures in BSL, we did not tell them the purpose of the task or which particular constructions we were interested in. Nevertheless, each of the 40 stimulus items elicited entity classifiers from each of the signers, with very little variation in the handshapes used, and no variation in orientation or location.

Each response was given an overall score of 1 if it matched at least one of the native signers' productions, and 0 if it did not, with the highest possible score being 40. In order to investigate which of the individual meaningful parameters of the classifier, that is, handshape, orientation, and location, were easiest to produce, each of these was also scored, and coded as either correct or incorrect. Handshape errors, which were the most

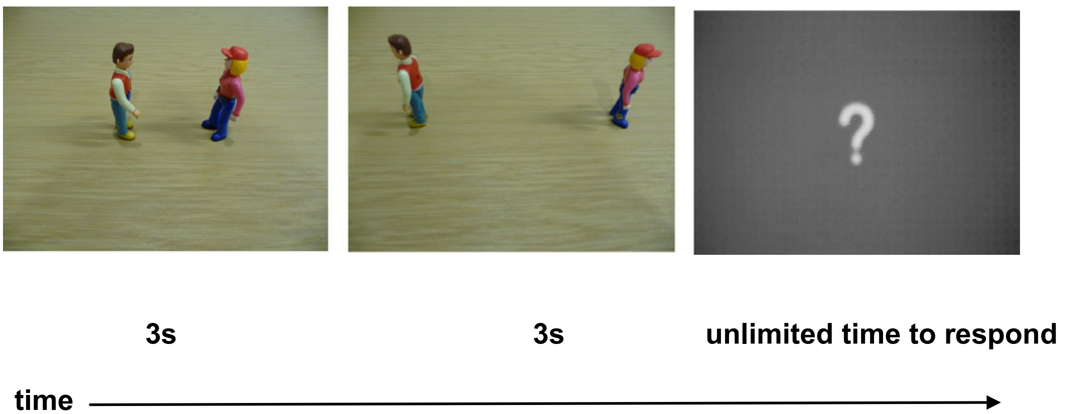

Fig. 2. Example of a locative trial from Study 1, showing a change in both orientation and location.

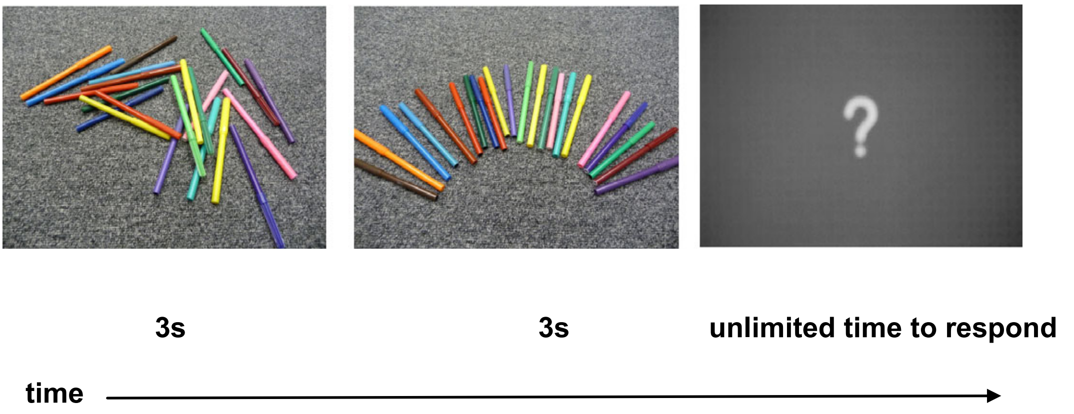

Fig. 3. Example of a distributive trial from Study 1, showing a change in distribution.

common, were further subdivided into two types: no classifier handshape ("omission") and a substituted handshape ("substitution").

For distributives, two additional errors were possible: anchor errors and movement errors. Many distributives require one hand to remain still while the other hand moves, so that together the two hands demonstrate the extent of the distribution. The static hand is an "anchor." Where a learner did not use an anchor, but all four of our native signers had, it was coded as an error. Movement was coded as incorrect if it had the wrong shape (e.g., if a circular arrangement of objects was indicated with a straight movement), or if movement was toward rather than away from an anchor. We coded using ELAN software (http://tla.mpi.nl/tools/tla-tools/elan/). Based on previous work on gesture (Singleton et al., 1993), we also coded points and lexical preposition signs. All the data were coded independently by two coders with advanced BSL skills, and any areas of disagreement were discussed until consensus was reached.

2.2. Results

One signer (who had only passed BSL Level 1) found the task particularly difficult and was not able to produce any classifier handshapes when describing the pictures, so testing was terminated before the end and her data were not used. The remaining 11 signers completed the task, and their data are presented in Figs. 4–7 and analyzed here.

2.2.1. Correct items and items containing classifiers

The data discussed in this section are illustrated in Fig. 4. In this figure and in those that follow, the error bars represent one standard deviation above and below the mean.

Locatives: Learners of BSL produced 32.43% (*SD* = 28.63) of the locative items correctly, in comparison to productions of the four native signers whom we also tested. This

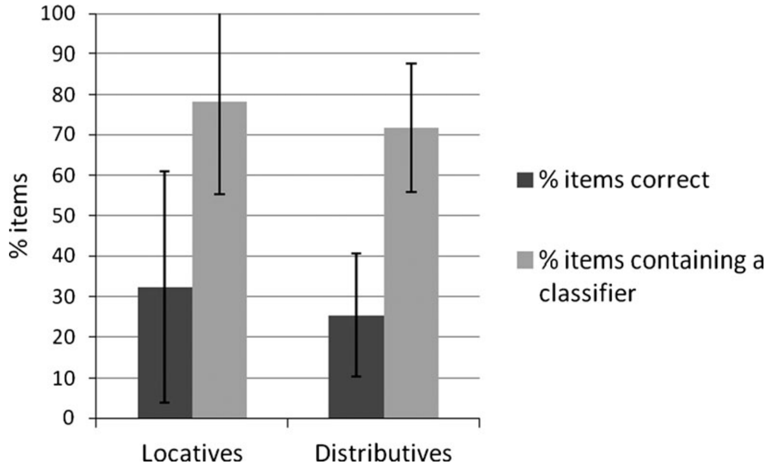

Fig. 4. Percentage of items correct and percentage of items containing a classifier (study 1).

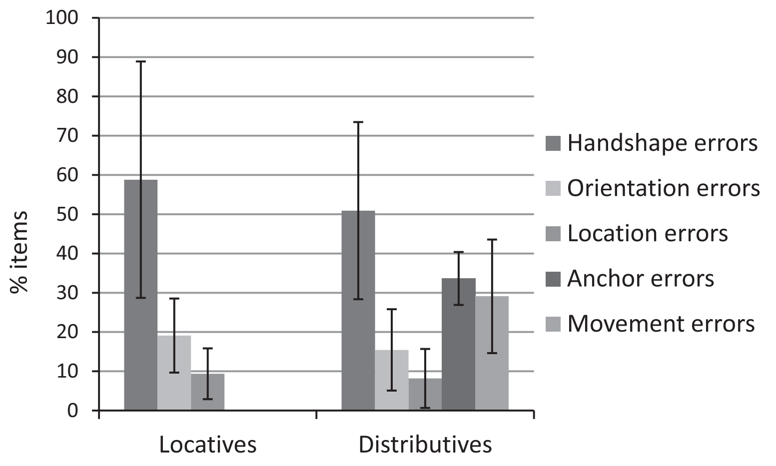

Fig. 5. Percentage of errors according to parameter (study 1).

mean percentage was low, and there was considerable individual variation. However, the learners did actually use their hands to represent objects: They used at least one entity classifier in 78.18% (*SD* = 22.90) of their responses. Again, there was considerable variation between signers. Nevertheless, the percentage of responses containing entity classifiers was significantly higher than the number of responses that were correct overall (paired samples *t*-test, $t(10) = 8.759$, $p < .001$).

Distributives: There was a similar pattern for distributives. Learners produced 25.45% (*SD* = 15.08) of the distributive items correctly, in comparison to native signers. However, learners used at least one entity classifier in 71.82% (*SD* = 16.01) of their

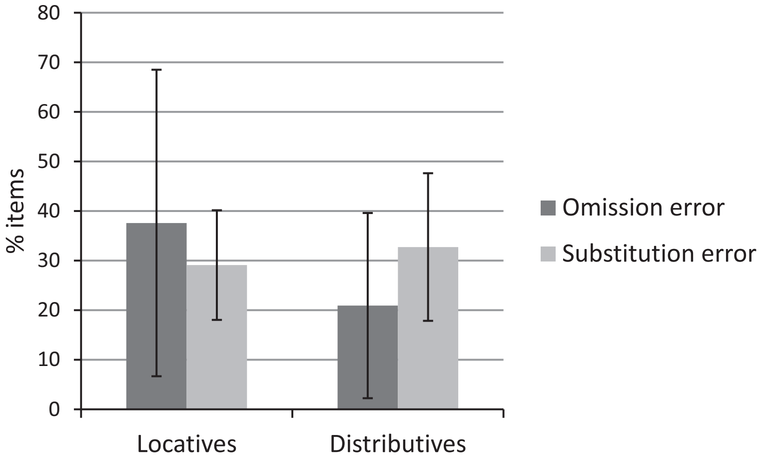

Fig. 6. Percentage of handshape errors by type (study 1).

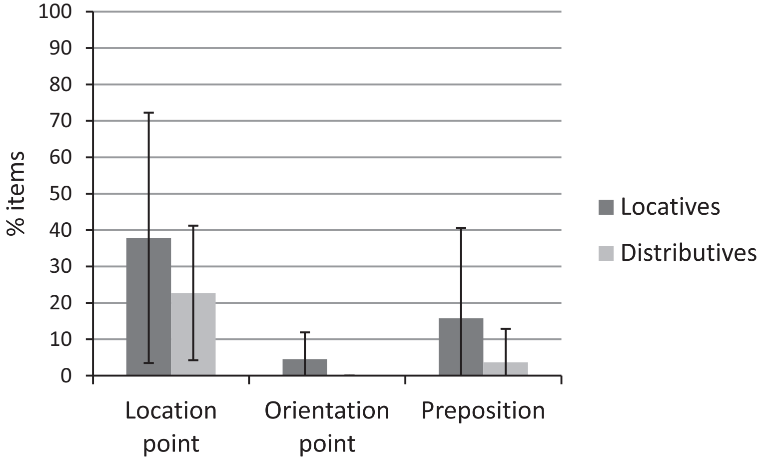

Fig. 7. Percentage of location points, orientation points, and prepositions (study 1).

responses. The percentage of responses containing entity classifiers was significantly higher than the number of responses that were correct overall, $t(10) = 19.007$, $p < .001$.

Comparison between locatives and distributives: There was no significant difference in the percentage of correct responses for locatives and distributives, $t(10) = 1.142$, $p = .280$. Nor was there any significant difference in the percentage of locatives and distributives that included an entity classifier, $t(10) = 1.154$, $p = .275$.

Thus, it appears that learners of BSL are generally aware that they need to use entity classifiers for encoding locative and distributive relations, but they have difficulty in doing so using the conventions that the language requires.

2.2.2. Error analysis

Next, the percentage of errors on each formational parameter (handshape, orientation, and location) was examined, for locatives and distributives separately, and for distributives anchor and movement errors were also analyzed. These data are presented in Fig. 5.

Locatives: Learners made handshape errors on 58.80% of items (SD = 30.10). They made orientation errors on fewer items, 19.10% (SD = 9.43), and location errors on still fewer items, 9.37% (SD = 6.47). The differences between all error types were statistically significant (for handshape vs. orientation, $t(10) = 5.559$, $p < .001$; for handshape vs. location, $t(10) = 5.876$, $p < .001$; for orientation vs. location, $t(10) = 4.276$, $p = .002$).

Distributives: Learners made handshape errors on 50.91% of items (SD = 22.56). They made orientation errors on fewer items, 15.45% (SD = 10.36), and location errors on still fewer items, 8.18% (SD = 7.51). The differences between handshape and the two other error types were statistically significant (for handshape vs. orientation, $t(10) = 6.500$, $p < .001$; for handshape vs. location, $t(10) = 6.456$, $p < .001$). For orientation versus location, the difference missed significance, $t(10) = 1.896$, $p = .087$.

There were two other error types that were possible for distributives but not for locatives, namely anchor errors and movement errors. 33.64% (SD = 6.74) of items had an anchor error, and 29.09% (SD = 14.46) of items had a movement error. We note that these error levels are significantly lower than the percentage of handshape errors, $t(10) = 2.297$, $p = .044$ for the comparison between handshape and anchor errors, and $t(10) = 3.387$, $p = .007$ for the comparison between handshape and movement errors. Orientation errors were, however, significantly lower—$t(10) = 4.451$, $p = .001$ for orientation versus anchor errors, and $t(10) = 2.887$, $p = .016$ for orientation versus movement errors.

Hence, for locatives the pattern of errors (in order of decreasing number of errors) is handshape > orientation > location, and for distributives it is handshape > anchor, movement > orientation, location.

Handshape errors occurred on over half of items, and we now investigate them in more detail (see Fig. 6). Errors were of two types: omissions and substitutions. For locatives, omissions of at least one classifier handshape occurred for 37.58% (SD = 30.92) and substitutions for 29.09% (SD = 11.06) of items, a nonsignificant difference, $t(10) = 0.891$, $p = .394$. For distributives, there were omissions of at least one classifier handshape for 20.91% (SD = 18.68) and substitutions for 32.73% (SD = 14.89) of items, again a nonsignificant difference, $t(10) = 1.759$, $p = .109$.

A variety of replacement handshapes were involved in substitution errors, with the most common being B (i.e., an open palm flat handshape). On occasion, learners were uncertain which handshape to use and would try out more than one when describing a pair of pictures. For example, when describing the two pictures in Fig. 2, one learner used two B handshapes to represent the people in the first picture (incorrectly), but two G handshapes for the second picture (correctly). When describing a single picture of a toothbrush in a cup, another learner used a G handshape (correctly) followed by a Y handshape (incorrectly) and finally an A handshape (incorrectly).

Some learners appeared to prefer to use a particular handshape over others, which meant that they encoded objects from several different classes using the same handshape, rather than differentiating them. However, all learners differentiated to some extent; none used just one handshape for the entire set of objects.

2.2.3. Strategies for encoding orientation and location when no classifier handshape was used

For locatives, learners were able to represent orientation and location information even when they did not produce a classifier handshape to stand in for the objects. They did so using two strategies: pointing with the index finger, and BSL prepositions, and these data are shown in Fig. 7. Points could be used to encode location. For example, one learner pointed at two locations next to one another to indicate that two magazines were located next to one another. More rarely, points were used to encode orientation. For example, one learner oriented her two index fingers to point toward one another in order to indicate that two people were facing one another. With respect to pointing, 9 of the 11 signers used points to encode location for at least one item, and 5 out of the 11 used points to encode orientation on at least one item. Learners used one or more location points for 37.88% (SD = 34.39) of items, and orientation points on just 4.55% (SD = 7.34) of items, a significant difference, $t(10) = 3.087$, $p = .011$.

Six learners used prepositions for encoding location in at least one of the items, and three used this strategy to a considerable extent (10, 17, and 20 times in the set of 30 items). This gave a group mean of 15.76%, and, not surprisingly, a large standard deviation, of 24.81. The BSL prepositions used included NEXT TO, ON, and IN FRONT OF.

For distributives, there were no orientation points, and BSL prepositions were rare and produced by only two learners (one learner produced 3 [NEXT TO × 3] and another produced 1 [ON]). Most learners (9 out of the 11) did produce location points, however, with a group mean of 22.73% (SD = 18.49) of items containing at least one location point. Although this percentage is numerically lower than that of location points for locative items, this difference missed significance, $t(10) = 2.089$, $p = .063$.

2.3. Interim discussion

The production task was challenging for learners of BSL. While they were generally very accurate in expressing location and orientation information in locatives and distributive plurals, they found the use of conventional BSL handshapes more problematic. The majority of their productions contained handshape omissions and substitutions. Distributives incurred two additional error types, errors of anchor and movement.

Learners combined both sign and gestures. Alongside entity classifiers, they used index finger points to locations and some lexical preposition signs. On occasion, learners appeared uncertain over which handshape to use, with several handshapes chosen to represent the same object, even within the same trial, or indeed individual pictures. However, no learners used a single handshape to represent all objects, and therefore all learners achieved some differentiation across different semantic classes.

Given that classifier handshapes proved so difficult for learners of BSL to produce accurately, an obvious next question is whether this difficulty is also present in comprehension.

3. Study 2. Comprehension of classifiers by learners of BSL

We next investigated whether handshape was more difficult than orientation and location for learners of BSL to comprehend.

3.1. Method

3.1.1. Participants

The same 12 learners who had participated in study 1 participated in this study. They completed the production task first, and then, after a short break, the comprehension task.

3.1.2. Procedure

The task was a picture-selection task, presented on a laptop, with recorded instructions signed by a native signer of BSL. Four pictures appeared simultaneously at the top of the screen, numbered 1–4 (see Fig. 8 for an example). Learners were tested individually. Once they had had the opportunity to look at all the pictures, they clicked on a video clip

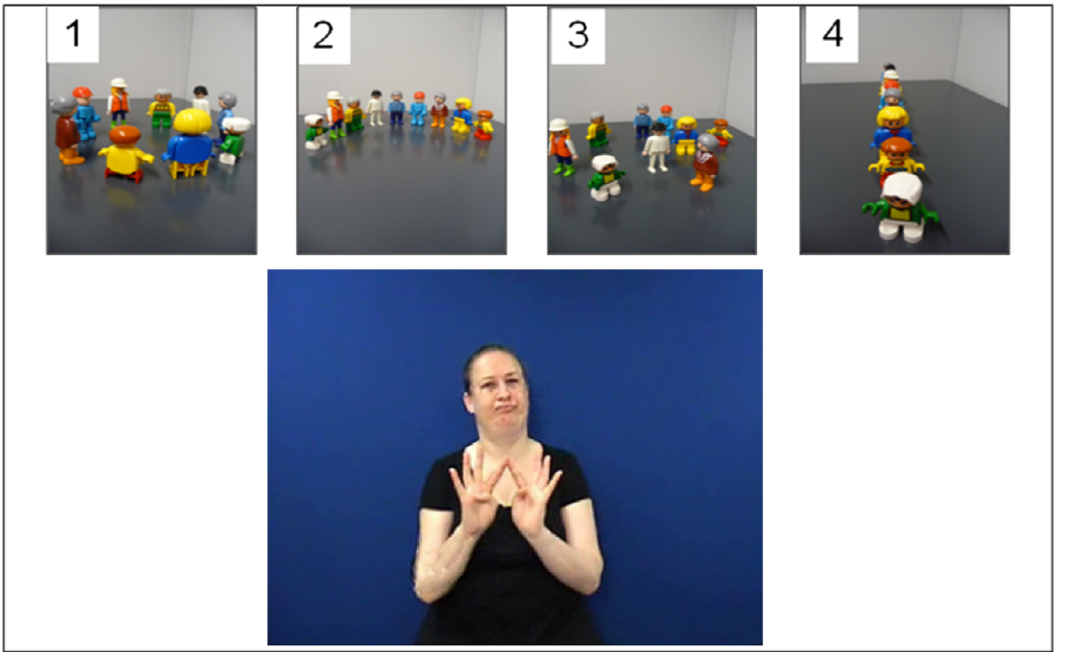

Fig. 8. Example of a distributive trial from Study 2.

below the pictures in order to watch the signer sign the entity classifier construction for one of the pictures, followed by the sign WHICH. They were allowed to watch the video only once, except on very rare occasions when there had been a very obvious distraction during the video, for example, if they or the experimenter sneezed, or if there was sudden noise outside the testing room. Having watched the video, learners then had to select the picture that matched what had been signed, by pointing to the correct picture, or by signing or saying out loud the number of the picture. This response was recorded by the experimenter. Learners moved onto the next trial when they were ready.

Three practice trials, testing individual vocabulary items rather than entity classifier constructions, were presented in order to get participants used to working the video clips and indicating the number of the matching picture. Learners were offered a short break halfway through. The task took approximately 15–20 min to complete.

3.1.3. Stimuli

As in the production study, we tested two types of classifier construction that involve entity classifiers: locatives and distributives. There were 84 trials in total. Twelve were distributives, where objects pictures were identical but varied in distribution (location and/or orientation; see Fig. 4). The remaining 72 trials pictured just two (or occasionally three) objects: 12 trials varied in handshape only, 12 in orientation only, 12 in location only, 12 in handshape and orientation, 12 in handshape and location, and 12 in orientation and location.

3.2. Results

The results are shown in Figs. 9 and 10. As before, error bars represent one standard deviation above and below the mean. Levels of accuracy were high overall for both

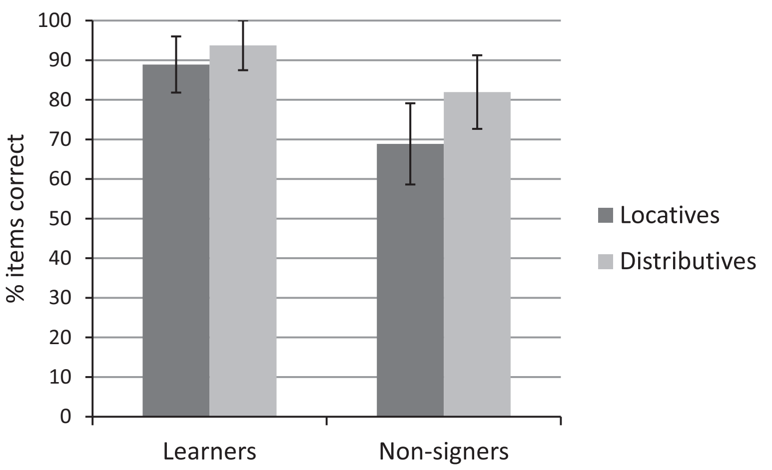

Fig. 9. Percentage of correct responses for learners of BSL (study 2) and non-signers (study 3).

locatives and distributives, although a paired samples t test showed that accuracy was significantly higher for distributives, $t(11) = 3.815$, $p = .003$. Comparing errors for locatives across the three parameters, handshape, orientation, and location, revealed no significant differences in the distribution of errors (for handshape vs. orientation $t(11) = 1.316$, $p = .215$; handshape vs. location, $t(11) = 0.733$, $p = .0479$, and orientation vs. location, $t(11) = 0.418$, $p = .684$).

3.3. Interim discussion

In contrast to the results of study 1, which showed that handshape is more difficult for learners to produce accurately than orientation or location, no differences in error frequency were found across the different parameters for comprehension.

It should be noted that the learners performed very accurately with this task (and reported finding it extremely easy), in contrast to their considerably less accurate performance on the production task (which the majority reported finding very challenging).

How much experience of signed language is required in order to perceive and comprehend the handshape contrasts shown in the BSL classifier system? Given how straightforward learners found the comprehension task, and the lack of relative difficulty for handshape compared to the other parameters, for our final study we investigated whether people who had never seen BSL would find the comprehension task as straightforward as sign learners, and whether they would show the same pattern of comprehension across the three parameters. This group would presumably be recruiting only their knowledge of gesture and their general visuo-spatial abilities when mapping the signer's classifiers to the pictures of objects, rather than any specific acquired knowledge of sign language. What this group comprehends successfully will reveal a part of the visual-gestural substrate that can transfer from gesture to sign during sign language conventionalization.

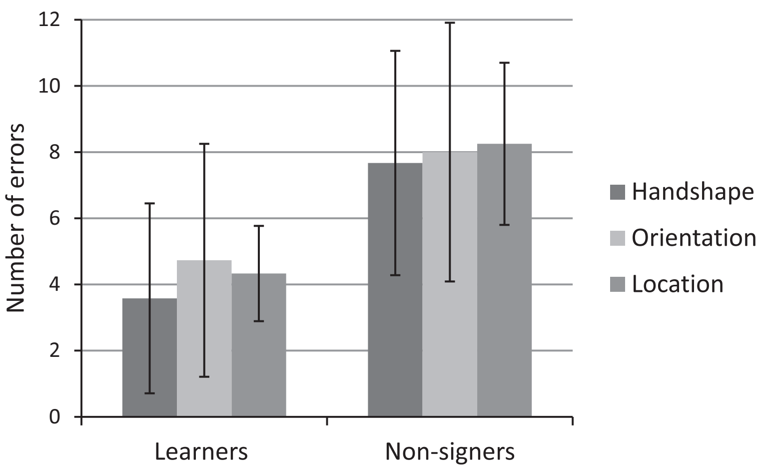

Fig. 10. Mean number of errors on each parameter for locatives, for learners of BSL (study 2), and non-signers (study 3).

4. Study 3. Comparing comprehension of classifiers in learners of BSL and non-signers

4.1. Participants

Twelve (two male) hearing adults participated. All reported having never learned any sign language, and their encounter with BSL, if any, was limited to seeing BSL interpreters on TV. The mean age of this "non-signer" group was 31.6 years ($SD = 6.1$; range = 23–41). There was no significant difference in age between the non-signers and the learner group who took part in studies 1 and 2, $t(22) = 1.305$, $p = .206$.

4.2. Procedure

The materials and procedure were the same as for study 2, except that the instructions were given verbally by the experimenter in English. Participants either pointed to the correct picture or said the number of the picture out loud.

4.3. Results

The data for the non-signers are presented in Figs 9 and 10, alongside those for the learners of BSL. We compared the non-signers' results to those of the learners reported in study 2. A 2 (classifier type: locative, distributive) × 2 (group: learners, non-signers) ANOVA revealed a significant effect of classifier type, $F(1, 22) = 21.913$, $p < .001$, $\eta_p^2 = 0.499$, and a significant effect of group, $F(1, 22) = 31.503$, $p < .001$, $\eta_p^2 = 0.589$, but no significant interaction, $F(1, 22) = 0.439$, $p = .515$, $\eta_p^2 = 0.020$. These results reflect higher performance by the learners, and greater accuracy for distributives. However, it should be noted that all the non-signers performed considerably more accurately than chance (25%).

For the locatives, we next investigated whether any phonological parameter was more prone to error, and whether the two groups made different proportions of errors. For locatives, a 3 (error type: handshape, orientation, location) × 2 (group: learners, non-signers) interaction between participant group and error type was not significant, $F(2, 44) = 0.224$, $p = .801$, $\eta_p^2 = 0.010$. Nor was there a significant effect of error type, $F(2, 44) = 0.777$, $p = .466$, $\eta_p^2 = 0.034$. Therefore, no phonological parameter was more likely to cause a comprehension error than any other, and this was the case for both groups.

4.4. Interim discussion

That the non-signers did so well and that their pattern of performance did not differ in any way from learners of BSL indicates that much in entity classifier constructions can be understood using general visuo-spatial skills and without any formal introduction to sign language. However, the finding that learners of BSL performed better than non-signers shows that language experience also plays a role in successful comprehension.

5. General discussion

Previous studies have revealed that the gestures used by hearers in co-speech communication and the entity classifiers used by signers share some similarities in form (Schembri et al., 2005; Singleton et al., 1993). Nevertheless, there are crucial differences relating to the complexity and conventionalization of sign languages compared to co-speech gesture. In co-speech gestures, speakers distribute semantic information across modalities, and while co-speech gesture is not random, it is produced without following any formal rules (Kendon, 2004). In addition, there is a substantial variation across speakers in how they use their hands when they gesture about space.

Entity classifiers, in contrast, are part of a system of contrasts and combinations, that is, a grammar. While the raw materials of such constructions might be gestural (Liddell, 2003), what makes them different is that they carry the full communicative burden and hence need to be part of a more elaborate system. In addition, they need to be understood by a linguistic community and so are required to be more homogeneous and are conventionalized. Interestingly, Singleton et al. (1995) observed that when hearing people have to gesture without using their voice in an experimental situation, gesture conventionalization begins to happen (within an individual speaker).

In contrast to previous studies such as those by Singleton et al. (1993, 1995) and Schembri et al. (2005), which have focused on hearing gesturers, in the series of studies reported in this paper we investigated hearing learners of BSL. How far do learners' existing gestural abilities and visuo-spatial cognition support them in acquiring the entity classifier system? Specifically, we investigated whether (a) expressing the relative locations of objects—something that gesturers find easy because the mapping between locations in the real world and the location of the hands in both gesture and sign is very direct—would be easy for learners of BSL, whereas (b) learning the appropriate handshapes to represent the objects would be harder, because handshape classes are a conventionalized system, and the handshapes used by gesturers and signers, therefore, frequently differ. We also investigated how accurately orientation of the hands (to represent the relative orientations of objects) is learned, and whether the same patterns that we found in production were also present in comprehension, not only for the same learners of BSL but also for hearing adults with no previous exposure to BSL.

To test comprehension, we devised a picture-pointing task whereby participants had to select the picture that matched a video of a signer's entity classifier construction. This task was completed with high levels of accuracy not only by the learners of BSL but also by hearing adults who had never seen BSL before, the non-signer group. The results from the non-signers demonstrate that there is a considerable part of spatial expressions in a signed language that can be understood via visuo-spatial, non-linguistic processing.

Nevertheless, the BSL learners were better at understanding these expressions than non-signers: Experience with BSL has allowed learners to go beyond raw visuo-spatial cognition. For both groups, the errors were distributed evenly across the three parameters, handshape, orientation, and location. Thus, in perception/comprehension each component of the classifier expression is equally accessible.

In contrast to comprehension, the production task (whereby participants had to express a change in relative location and/or orientation of objects, or a change in distribution of many objects of the same kind) was difficult for learners of BSL. On only approximately one-third of occasions did their classifier constructions match those of native signers. Learners knew they had to use the hands to represent different objects, and they did so for most of the trials across the test, but their overall levels of accuracy compared with native signers were low. Additionally, and unlike for the comprehension task, the errors that they made were not distributed equally across handshape, orientation, and location. The learners' pattern of difficulties with handshape, but not location, is the same as has been described in previous studies of gesturers' expression of motion events. Additionally, we found that orientation information was encoded more accurately than handshape, but less accurately than location.

Iconicity has previously been shown to be important for learners of signed languages learning lexical signs (Baus et al., 2013; Campbell et al., 1992; Lieberth & Gamble, 1991). Within entity classifiers, the pattern of handshape being expressed least accurately and location most accurately is what we would expect to find if classifier learning is related to iconicity. Location is the most iconic component of entity classifier constructions, with a direct mapping between the relative locations of objects in the real world and the relative locations of the hands in signing space. Handshape, however, is less iconic, because the mapping between the shapes of real objects and the shape adopted by the hands is less direct. Furthermore, entity classifier handshapes are conventionalized, and our learners showed evidence that they were still learning these conventions. Further evidence for this in our data was the use of different handshapes to represent the same object.

Schembri et al. (2005) made a similar observation. They reported that both the signed and gestured descriptions of motion events by deaf and hearing individuals, respectively, in their study expressed imagistic aspects of thought (i.e., the mental representation of motion events) by means of forms created to conform to that imagery. For Schembri et al. (2005), what distinguished the two groups is that signers are able to do this more consistently. Our data reveal that even after a period of 1–3 years of learning BSL, that consistency has still not been achieved.

Previous research on non-signers has also described non-specific gestures and points when gesturing motion events without voice (Schembri et al., 2005; Singleton et al., 1995). In BSL learners, we observed the continued recruitment of these two devices. Even when classifier handshapes were omitted, location and orientation could be successfully encoded, either through the use of BSL prepositions or, more commonly, through the use of points. While points and prepositions do form part of BSL, none of the four native signers used this strategy when signing our stimuli.

5.1. From gestures to signing in BSL learners

One proposal for how entity classifier expressions emerged in many sign languages is that they are conventionalized forms of iconic gestures used by hearing people, who were frequently the initial communication partners of deaf people (Morford & Kegl, 2000; Pfau & Steinbach, 2004; Zeshan, 2003). Once these classifiers are in the sign language they enter into syntagmatic relationships with other signs to form clauses and clause complexes. Fischer (1978) and Schembri et al. (2005) suggest that the peculiar patterns of language transmission in deaf communities (few deaf signers acquire sign language from deaf signing parents because most are born into hearing families) mean that each generation may partly recreolize the language. This, coupled with the greater capacity of the visual-gestural modality for iconic representation (referents and hands both exist in space; referents can have different shapes, and so can hands), might mean that some aspects of classifier constructions do not move far from their gestural origins.

In our classifier comprehension experiment, the non-signers were able to grasp the gestural origins of the spatial information expressed by the hands in BSL. These image-provoking elements are candidate raw materials for the first forays into classifier production we observed in BSL learners in our production study. Learners use their hands to describe space, including using points. But these devices need to become part of a coordinated system following particular linguistic conventions. Gesture provides the substrate or the tools that learners recruit to sign with initially, but this system needs to be reorganized for further development toward the system used by native signers.

What the learners of BSL are still acquiring is the ability to represent a set of objects in a coherent and systematic fashion. Singleton et al. (1993) noted that their gesturing non-signers used several different handshapes to represent the same category of object. The learners who participated in our study were still coming to grips with the constraints placed on handshape choice by the BSL classifier system. For them it appears that the challenge is not to represent information in the visual modality; instead, it is to acquire the internal organization of information using a set of contrastive handshapes.

Our group of 12 learners was relatively small, and they varied quite widely in their performance on our tasks, which was not surprising, given that they had been learning BSL for different lengths of time and that some had more regular exposure to BSL than others. For future work it could be valuable to follow learners from their first sign language classes until they become advanced signers, in order to examine the time course of classifier acquisition from the very initial comprehension and production of such constructions to their mastery, and in order to examine the amount and type of linguistic input that is needed.

Furthermore, in signed conversation and narratives, entity classifiers are frequently used simultaneously with constructed action (also known as role shift), whereby the signer uses his or her head, face, arms, and torso to represent the thoughts, feelings, or actions of a referent (Cormier, Smith, & Sevcikova, 2013). Such simultaneous constructions make systematic use of multiple roles and perspectives, and would be predicted to create an additional challenge for learners, both in comprehension and production.

In conclusion, we argue that adult learners of BSL bring their visuo-spatial knowledge and gestural abilities to the tasks of understanding and producing constructions that contain entity classifiers. These abilities can be recruited for "breaking into" such constructions. We speculate that investigating adult sign language acquisition from initial co-speech gesture to fluent sign use might shed light on how gesture became conventionalized during the genesis of sign languages.

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