Hand Preference as Evidence for Laterality of Language in the Early Stages of Sign Language Acquisition

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Abstract

Sign language provides us with a clearly linguistic manual activity, signing itself, with which to examine the relationship between hand preference and language. Results from a study of handedness in one child acquiring a sign language provides suggestive evidence for this relationship (Vaid et al.,1984). In the present study, the manual activities of two signing children and two non-signing children were analysed. The children were filmed monthly from 6 to 18 months of age. Unimanual activities were coded and categorized into the following six types: signs, sign babbling, points, empty-handed gestures, actions with objects and motoric activities. A strong right hand preference for signs was found for both signing children. The degree of handedness for signs was substantially greater than that shown for all other manual activities. This result provides supporting evidence for the early lateralization of language.

Background

Children show clear evidence of a hand preference from 3 years of age although the degree of hand preference continues to increase until approximately age 7 years (McManus et al, 1988). There is substantial evidence that children younger than 3 years also show a hand preference (Archer, Campbell, Cunningham, & Segalowitz, 1987; Caplan & Kinsbourne, 1976; Fogel & Hannan, 1985; Petrie & Peters, 1980; Ramsay, 1979; Young, Lock, & Service, 1985).

The link between handedness and language stems from the observation that most right-handed adults are left-lateralized for language. The motor control of the right hand is presumed to come

primarily from the left motor cortex (a simplification, but likely true for unimanual distal actions such as hand movements -- Lemon & Porter, 1976).

This connexion between language and handedness in the development of children was of interest historically (see Harris, 1982); however it was Lenneberg who rekindled interest by speculating on the relationship between language and handedness in light of present day concerns. Lenneberg (1967) claimed that the left hemisphere became more lateralized for language as the child matured. Initially, the hemispheres were equipotential with regard to their ability to subserve language. As language acquisition proceeded language became more and more lateralized to the left.

Recent research challenges Lenneberg's hypothesis and proposes instead that lateralization is invariant throughout development. Although the child may display a greater plasticity in recovery from brain lesions, this is not to be confused with an equipotentiality of the hemispheres for a particular functions (for reviews see Curtiss, 1985; Kinsbourne & Hiscock, 1983). Experimental evidence supporting the hypothesis of early or invariant lateralization has come from a number of different directions. A few of these studies are explored below.

The relationship between vocalizations and handedness has been examined by Ramsay (1983, 1984). In both longitudinal and cross-sectional studies he found unimanual handedness preferences to emerge in conjunction with babbling. He proposed that these results reflect the increasing lateralization of the left hemisphere.

Bates, O'Connell, Vaid, Sledge, & Oakes (1986) studied the relationship between handedness and symbolic manual activities (culturally appropriate actions with objects, such as stirring a spoon in a cup), non-symbolic manual activities (such as banging a spoon or reaching for an object), and pointing. In a cross-sectional study of 13, 20, and 27 month olds, they found that a right hand

preference was evident for both unimanual and bimanual tasks. In addition symbolic manual activities showed a greater right hand preference than non-symbolic manual activities. This was not a robust finding however, as the same analysis was non-significant when conducted with a reduced subject group (n=17 instead of n=24).

Bates et al. (1986) also predicted that because symbolic gestures are more "symbolic" or "language-like" than pointing they would show a greater right hand preference. The data presented by Bates do not support this prediction. An alternative explanation of this finding is not offered. Instead, they conclude that both pointing and symbolic manual activities are more right handed than non-symbolic manual activities because they are "compatible with linguistic processing".

Finally, a study by Vaid, Moriarty & Bellugi (1984) was the first to truly examine the relationship between handedness and language *per se*. In this study two deaf children acquiring a sign language (American Sign Language) from their deaf parents were followed to determine if they showed a consistent hand preference for signing. One child came from a left-handed family yet was right-handed herself. The data from her acquisition of signs is somewhat confused with respect to handedness but did show an overall laterality index of 0.21 for signs, indicating a right-hand bias (see Results for an explanation of the laterality index). This was a greater degree of right hand use than was found for her non-linguistic manual activities (LI = -0.03, indicating approximately 50% right hand use).

More interesting is the handedness of the child from a right-handed family who was right-handed herself. Her laterality index for signs is 0.98, indicating a strong, almost exclusive use of the right hand to produce signs. The laterality index for this child's non-linguistic manual activities is 0.44. This clearly indicates a

right hand bias; nevertheless, it is much weaker in degree than that exhibited for linguistic manual activity. This study implies that a clear relationship between handedness and language does exist when measured in a truly linguistic task. A cross-sectional study of signing children 3 to 8 years of age confirm these results (Bellugi, Klima, Lillo-Martin, O'Grady & Vaid, 1986).

Predictions

Results from Vaid et al. (1984) provide evidence for the relationship between language and handedness. Sign language provides us with a clearly linguistic manual activity, signing itself, with which to examine hand preference. Previous studies have examined the relationship between language and handedness in more indirect ways, for example, correlating handedness for object manipulation with onset of babbling (Ramsay, 1983).

The strong right hand preference for signs indicated in Vaid's study is the pattern of one child's sign acquisition. In the present study, data from two signing children of deaf parents will be analysed to determine if a similar pattern occurs across children. If this pattern is robust, then it provides evidence for lateralization of language at the first word stage in normally developing children.

It would be interesting to find a way of testing lateralization at an even younger age than one year. Research conducted in our lab leads us to conclude that children of signing parents produce a manual babbling we call *sign babbling* beginning in the period immediately preceding their first signs (Marentette, 1989; Marentette & Petitto, 1989; Petitto, 1987; 1988; Petitto & Marentette, 1989). Sign babbling is the production of meaningless manual activities that are constrained by the syllabic and phonetic properties of signed languages. If babbling is continuous with language acquisition then we should see a right hand preference

emerge even earlier than first signs. This result would imply a very early lateralization of linguistic functions in the left hemisphere.

Finally, the differences in hand preference for signing and for motoric activities implies that the more right-handed an activity is, the more likely it is tapping some left lateralized resource, presumably language. This provides us with upper and lower limits on a continuum of "language-like" manual activities. The existence of this continuum allows us to compare different manual activities such as pointing and the symbolic activities discussed by Bates et al (1986).

To summarize, the present study was designed to address the following questions:

1. Is there evidence for a strong right hand preference for sign production from the beginning of a child's language acquisition?

2. Is there evidence of a right hand preference for a pre-linguistic activity such as sign babbling?

3. Where do pointing and "symbolic" activities fit on the handedness continuum? What does this tell us about the "language-like" nature of these activities?

Method

Subjects

Four children of right-handed families were filmed between the ages of 6 and 18 months. All of the children were girls. All of the children had normal hearing. Two children came from families where a sign language was the primary language in the home as their

parents were deaf. One child, Sarah, was acquiring ASL (American Sign Language), the second child, Irène, was acquiring LSQ (Langue des Signes Québécoise). The other two children came from families with hearing parents. One child, Michèle, was acquiring French, and the second child, Donna, was acquiring English.

Procedure

The children were filmed either in the lab or at their home. Each filming session lasted approximately 45 minutes to one hour. An effort was made to use the same toys at the same ages for all of the children. Toys were chosen at each session to reflect the children's developing abilities and to elicit gestural and linguistic productions. After approximately 5 minutes of warm-up time, the experimenter, parent and child played with the chosen toys for approximately 30 to 40 minutes. Following this period and attempt was made to engage the parent in conversation in order to film the child playing by herself.

Coding

All unimanual activities were coded for a 20 minute period following the first 5 minutes of the tape.

A unimanual activity was defined as the use of one hand to perform a specific manual activity. Activities where both hands were used to manipulate a single object were not coded in this study. Instances where both hands were performing activities with different objects were coded as simultaneous instances of unimanual activities.

There was one exception to this rule. All instances of pointing were coded regardless of the type of activity (unimanual or bimanual) in which they occurred.

Each manual activity was coded for the form of the activity, the hand performing the activity, the object involved, presence or

absence of an object in the other hand, eye gaze, and presence or absence of vocalizations. Inter-rater reliability ranged from 87.5 to 100%.

After the manual activities were coded they were classified into the following six categories:

1) **Points** - communicative indexical manual activities
2) **Signs** - lexical items of a sign language, either ASL or LSQ
3) **Sign babbling** - hand movements reflecting the phonological and syllabic features of signed languages. Sign babbling has no conventional meaning, or referent.
4) **Motoric** - nonindexical manual activities drawn from the child's natural activities, including drop, reach, take, touch, move, give, show, and push (push book away)
5) **Actions with objects** - these are nonindexical manual activities with particular objects, including bang, pull, push (e.g., push car), comb, shake, turn page, open, draw, sweep, pull, pick up phone, dial and throw
6) **Empty-handed gestures** - these gestures are instrumental manual activities, used to effect some change in the environment. These gestures included raise arms, wave, open-close, and flap arm

Results

A laterality index (LI) was calculated for each of the six types of manual activity at each age for each child. This score is calculated by subtracting the number of left-handed activities from the number of right handed activities and then dividing by the total number of activities (R-L/R+L). This produces a number ranging from -1.00 (a exclusive left hand preference) to +1.00 (a exclusive right hand

preference) with a score of 0.00 indicating no hand preference or equal use of right and left hands.

Motoric. A weak right hand preference was displayed by all of the children by 10 months of age. This hand preference was remarkably stable within and across children. The average laterality indices across all ages for each child were as follows: Donna = 0.38, Irène = 0.21, Michèle = 0.34, and Sarah = 0.32. This is based on an average of 673 tokens of motoric activity per child (range = 410 to 1354 tokens).

Actions with objects. Hand preference for actions with objects was much more variable within and across children. Donna showed a strong right hand preference, LI = 0.75, based on 90 tokens. However, at three sessions there were less than 10 tokens produced. This produces a strong bias for the overall LI which may be unwarranted given the number of tokens. If these three sessions are excluded from the average the LI becomes 0.49 (78 tokens), more in line with the other children's data. Irène showed a weak right hand preference for actions with objects, LI = 0.17, based on 220 tokens. This is comparable to the hand preference she displayed for motoric activities. Michèle demonstrated a right hand preference, LI = 0.48, based on 163 tokens. Sarah varied a great deal from age to age with an overall LI = -0.03, based on 171 tokens. This includes one data point with less than 10 tokens. If this is removed her LI becomes 0.13 (169 tokens).

Empty-handed. Few items were produced in this category. The total number of tokens was 56 for all children. For this reason laterality indices are not provided. It is unlikely that any reasonable conclusions regarding handedness could be made from this amount of data.

Points. Strong right hand preferences were displayed for pointing by all four of the children. The average laterality index for each child was as follows: Donna = 0.54, Irène = 0.58, Michèle = 1.00, and Sarah = 0.59. Clearly Michèle's exclusive right hand use deserves some comment. Her LI is based on a very few data points (n = 33) and only one session has more than 10 points in it. The average number of tokens for the other children was 136 (range 98 to 191). An additional comment is that Irène demonstrates a weak left hand preference for pointing at 11 and 15 months. This is not mirrored in any other manual category at any other age. Finally, it is noteworthy that (excluding Michèle) the overall degree of right hand use for pointing is very similar across the children.

Signs. Only two children produced signs. Irène, who was growing up in an LSQ family, was not a prolific signer. Her first signs were at 11 months and there is a total of 23 signs in here entire corpus. The laterality indices for Irène's signs are presented in Figure 1.. The average LI equals 0.53. During the one session in which she produces more than 10 tokens (age 16 months) she uses her right hand exclusively. Later sessions with this child have been filmed and, although they are not yet analysed, there is a clear trend. Irène uses her right hand almost exclusively to produce all her signs. Her mother has also volunteered this information a number of times.

Sarah, acquiring ASL, provides a much clearer picture of sign acquisition as she is a great communicator. Her first signs were produced at 12 months. In the four sessions in which she signs, she produced 100 instances of 35 different signs. The laterality indices for Sarah's signs are presented in Figure 2. Her average LI equals 0.83, demonstrating a strong, consistent right hand preference.

Sign Babbling. The hand preference for sign babbling was quite different for each child. Irène showed a variable right hand

preference, displayed in Figure 3. The average laterality index was 0.43, however this was based on a total of 39 tokens. Although a right hand trend is apparent, there are insufficient data to rely on this result. A quite different pattern occurred for Sarah's sign babbling, this can be found in Figure 4. Sarah hand preference swings from left to right quite freely, and as a result there is no consistent hand preference. Her average LI is 0.15 based on 60 tokens of sign babbling.

Comparison of manual activities. Given the demonstrated hand preferences for motoric activities and signs, it is now possible to situate actions with object (or symbolic activities in the Bates terminology) on a continuum of "language-like" manual activities. Figure 5 presents the right hand use of non-signing children (Donna and Michèle) for manual activities The data have been averaged across the two children into three age categories. A clear distinction can be observed between the three types of manual activity. Pointing shows the strongest right hand preference, followed by actions with objects. Motoric activities provide a consistent baseline of 60%-75% right hand use.

The right hand use of signing children (Irène and Sarah) is presented in Figure 6. A consistent 60%-65% right hand preference for motoric activities is demonstrated. However the signing children show a different pattern of hand use for actions with objects, using right and left hands approximately equally often. Pointing shows a strong right hand preference, similar to the findings for non-signing children. The 14-18 month entry for points is lower than expected due to one data point for Irène at 15 months where she exhibits a weak left hand preference for points. This lowers the average for the 14-18 months entry. Finally, signing shows the strongest right hand preference of any manual activity.

Conclusions.

1. Evidence for a strong right hand preference for sign production which increases through to 16 to 18 months of age was demonstrated by both signing children.

2. No consistent hand preference was demonstrated for sign babbling among the signing children. One child showed a varying right hand preference., the other vacillated between left and right hand use.

3. Pointing was found to demonstrate a strong, consistent right hand bias. The degree of right handedness was less than that for signs and greater than the right hand bias for any other manual activity, including actions with objects. Actions with objects differed in degree of handedness for signing and non-signing children. The signing children showed a very weak right hand preference, less than the hand preference displayed for motoric activities. The non-signing children displayed a stronger right hand preference for actions with objects than for motoric activities. The degree of hand preference for motoric activities was consistent across signing and non-signing children.

Discussion

The results of this study, in conjunction with the work of Vaid et al. (1984), provide direct support for a connexion between language and handedness. Signing children from right-handed families show a strong right hand preference for sign production from the earliest stages of language acquisition. The study of sign language acquisition provides an ideal method for testing the connexion between language and handedness in normally functioning children.

This research contributes to the growing evidence for early cerebral specification for language.

The inconsistent hand preference demonstrated for sign babbling was not a predicted result. We are currently in the process of collecting additional sign babbling data. The results of the future analyses will be discussed in greater detail in a forthcoming paper.

The data do provide evidence for a handedness continuum of manual activities. Our data replicate the findings of Bates et al. (1988) demonstrating a greater right hand preference for pointing than for actions with objects. The implication is that actions with objects are not symbolic, or even referential, as they occur lower on the continuum than pointing. This finding will also be discussed in greater detail in the above mentioned forthcoming paper.

In conclusion, this study presents strong support for the early lateralization of language in the left hemisphere.

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Figure 1. Irène - Laterality Index for Signs

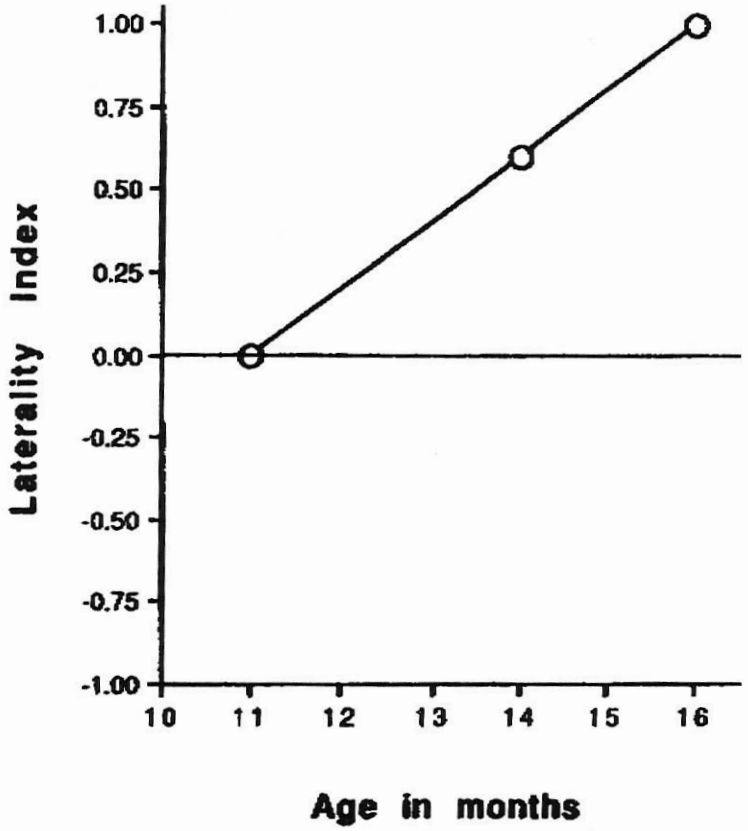

Figure 2. Sarah - Laterality Index for Signs

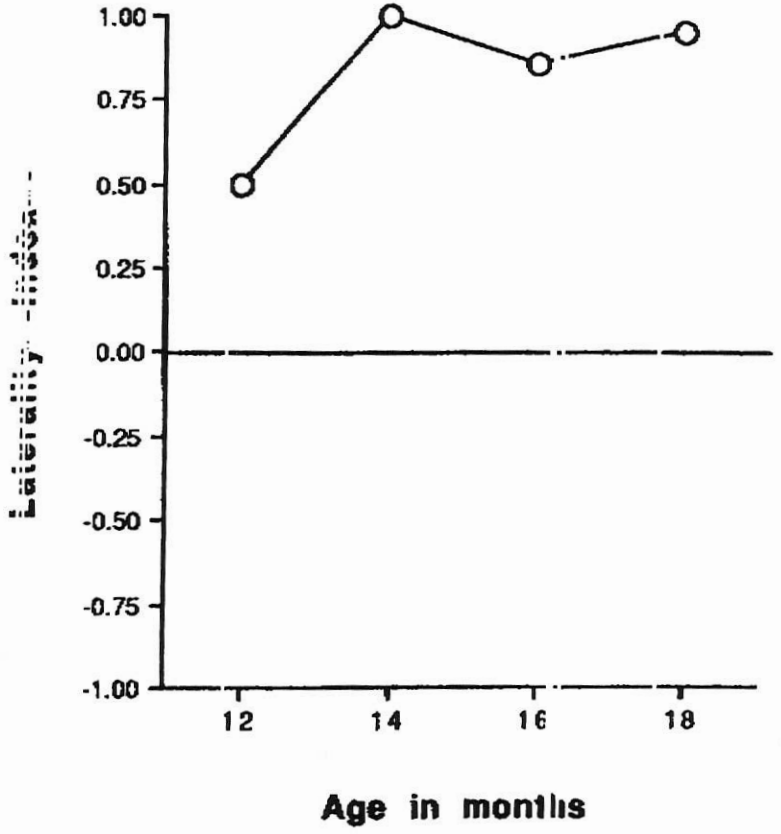

Figure 3. Irène - Laterality Index for Sign Babbling

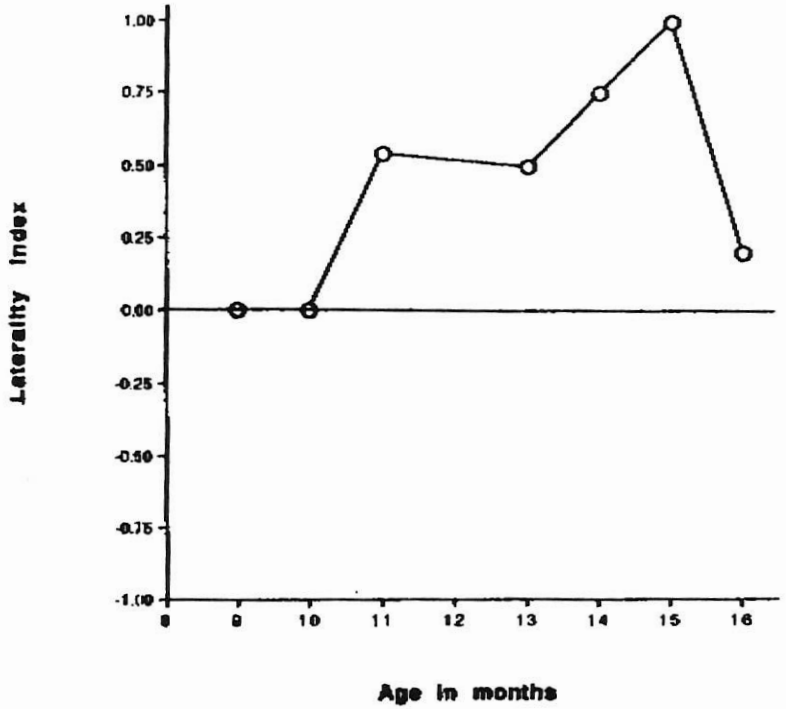

Figure 4. Sarah - Laterality Index for Sign Babbling

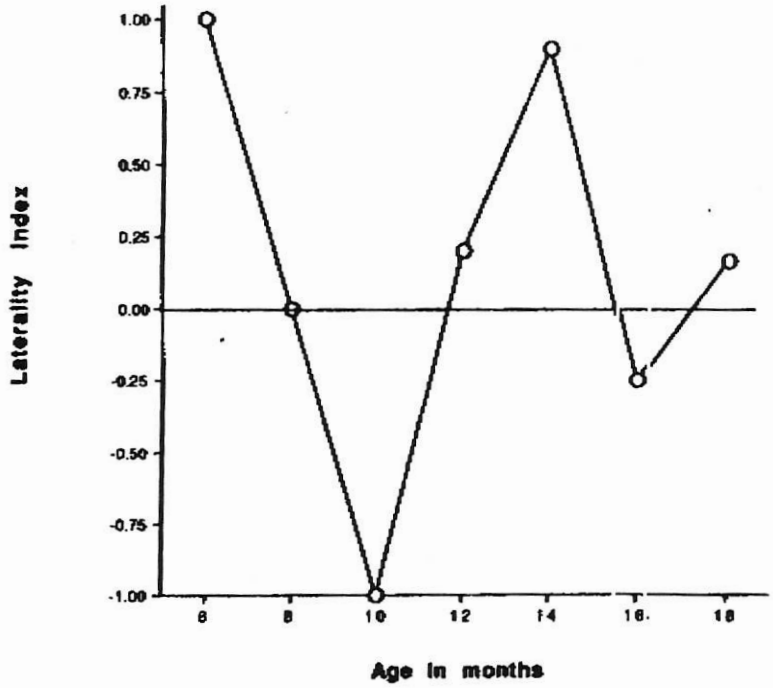

Figure 5. Right hand use for non-signing children

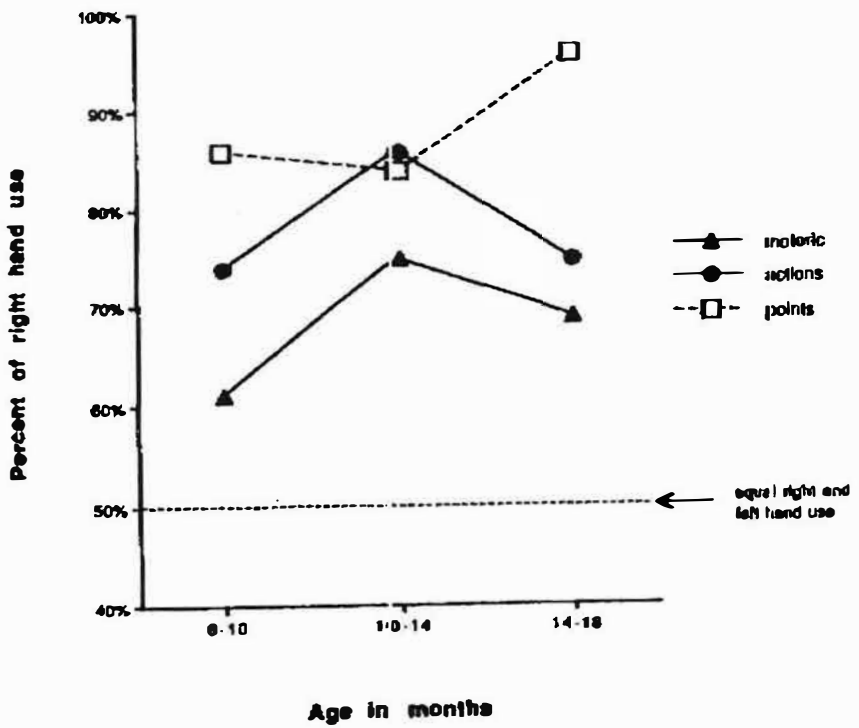

Figure 6. Right hand use for signing children