Pointing in Parent Input during Interactions with Deaf Children in American Sign Language

Julia Leary, Paris Gappmayr, and Amy M. Lieberman

1. Introduction

Pointing gestures are an important referential cue within parent input for helping children connect words to objects. Studies of interactions between hearing parents and children show that pointing facilitates word learning by directing the child's gaze to objects and explicitly linking labels to referents (Kalagher & Yu, 2006). The frequency and function of pointing in parent input has been shown to influence the child's use of pointing gestures and lexical development. Parents who use more pointing gestures also talk more during interactions, and the majority of these pointing gestures are used to direct attention (Rowe, 2000). However, much of the prior research on pointing has focused on its use with hearing children acquiring spoken language. In the current study, we investigate how pointing is used by parents interacting with their deaf children in American Sign Language (ASL).

Pointing cues have been studied for their role in establishing moments of joint attention, which is when two interlocutors achieve shared focus of attention on an object or activity. During these episodes, the child's ability to link language input to the object or event of focus is supported by shared attention with the adult (Tomasello, 1988). Language input that occurs during moments of coordinated joint attention is most likely to lead to word learning (Tomasello & Farrar, 1986). Yu et al. (2019) found that *sustained* attention during joint attention interactions with nine-month-old infants predicts vocabulary size at 12 and 15 months. A study of adult cues during interactions with preschool children reveals that word learning is best supported in the context of responsive, child-led interactions, emphasizing the importance of joint engagement during word learning (Hadley, 2019).

Given the importance of joint attention for language learning, it is critical to understand how parents support children's attention to both objects and language during episodes of joint attention. For hearing children, parents can provide language input *while* the child is gazing at or handling an object. In contrast, deaf

children learning ASL perceive both referential and linguistic information visually, and so parents must cue in sequence. Deaf children, in turn, must learn to shift their visual attention for successful association between a signed label and its referent (Lieberman et al., 2014). One way that parents might support children in learning how and when to direct their visual attention is to use pointing cues before or after a sign label, making the connection between the label and referent explicit.

While in spoken language parents may point to an object *while* they label it, in ASL the label and the point must occur in sequence. A point-label sequence is only successful at establishing the connection between the label and object if the child shifts their visual attention to capture both the referent of the point and the signed label. The child must access both of these informational components by learning to efficiently divide attention between the adult and the objects in their surrounding environment. There are multiple options for how the sequence is structured: a point may occur before the label, after the label, before *and* after the label, or between two labels. It is unknown what type of sequence is most effective in promoting word-referent mapping in the child.

Though its usage in sign language is complex, pointing has not been closely examined in parent input during interactions with deaf children in ASL. Points in ASL can be used to direct attention, like in spoken language, but points also serve linguistic functions, primarily as pronouns. For example, if a parent points to a train and signs TRAIN, the translation is roughly "That's a train." Fieldsteel et. al (2020) investigated the prevalence and function of parent's points, particularly pronominal points, in play interactions with deaf children in ASL. They found that only half of parent utterances that contained a point included the referent label; in the other half of utterances, parents pointed to an object but did not explicitly name it. This provides some insight into parents' use of points in ASL interactions, however it remains unknown how the organization and sequence of points and object labels in the input supports children's visual attention.

1.1. Current study

We analyzed pointing relative to object labels in parent ASL input during naturalistic play with deaf children. We hypothesize that points will occur with and without corresponding referent labels based on findings from Fieldsteel et. al (2020). Within the subset of pointing episodes containing labels, we identify the sequential organization of points and labels to determine the frequency and success of different sequence types. By looking at how parents sequence points and labels in combination with child gaze, we can identify which sequences are most effective in supporting children's ability to perceive both labels and their referents. We use child gaze to assess the extent to which children perceive the information required for word-learning. Without access to both the referent and label, a connection between these elements cannot be made and so it is unlikely children can easily map the label onto its referent. Thus, in the current study we consider successful sequences to be those in which the child perceives both the label and the referent object in sequence.

The overarching goal of this study is to identify how parents use pointing cues during interactions with deaf children, and to determine the optimal sequence of points and labels for word learning in a visual language. The current study is guided by the following three research goals and related questions:

(1) *Identify pointing sequences*: What kinds of pointing sequences do parents produce? In pointing episodes with labels, is the label given before or after the point, or both?

(2) *Determine overall success of pointing sequences*: How successful are pointing sequences with labels? Do children shift gaze between the label and referent in order to perceive both?

(3) *Identify factors affecting sequence success*: Does child age or sequence type predict success? Are there differences in pointing sequence frequency or success based on child age or parent hearing status?

We predicted that children would be most successful at capturing both the label and referent in a sequence where the label comes both before the point to the referent. During play the children's visual attention is likely focused on objects in their environment, so perception of the label requires disengaging attention from these objects to look at the adult signing the label. In addition, we predicted that older children would have a higher percentage of successful sequences than younger children, because they are more adept at managing their visual attention during interaction.

2. Methods
2.1. Participants

Participants were 24 parent-deaf child dyads. Children ranged in age from nine to 60 months (mean = 35 months), including 16 males and eight females. Children were all identified as having mild/moderate to profound hearing loss. Parents were deaf (n = 15) or hearing (n=8), and all reported using ASL in the home. Half of the children used hearing aids. All children had exposure to ASL at home and through early intervention programs where ASL was the primary form of communication. Thus, all children participating in this study had early language access and were learning ASL as their primary language. The participants were part of a large scale study of parent-child interactions in ASL investigating visual attention and language acquisition in deaf children.

2.2. Procedure

Play sessions took place at the child's school or at a community center. Parents were provided with a set of toys by the experimenter and instructed to play with their children as they normally would. All dyads were given the same set of toys, which included a fruit set, a farmhouse and animals, a Lego train, a birthday cake, and toy cars. Play sessions were approximately 15 minutes long, during which children and parents were free to select and use any of the toys in

the provided set. Each play session was video recorded using three simultaneous camera angles to capture parent and child eye gaze, object manipulation, attention-getting cues, and language production. Twelve minutes form each recording was transcribed and coded offline using ELAN (Crasborn & Sloetjes, 2008).

2.3. Initial video coding and transcription

As part of the larger study, each interaction was coded for linguistic and visual information. ASL coding was completed by deaf signers to capture all spontaneous ASL signs and attention getting cues by the parent and child. Signs were transcribed using glossing conventions from ASL Signbank (Hochgesang et al., 2020). All points (glossed as IX) were transcribed as part of ASL coding. Visual coding was completed after ASL coding, and included parent and child eye gaze and object touch in the two seconds before and after each ASL sign. A portion (25%) of each interaction was coded for both ASL and visual information by a second set of coders to determine inter-rater reliability.

2.4. Pointing episode coding

The annotated data was exported to Excel for further coding and analysis. For the present study, we analyzed all points to objects in the toy set and accompanying parent ASL signs labeling objects. Points to child and self were omitted, as were points and labels where child eye gaze was coded as "unknown" or "unclear" during the sign production. Object labels included noun and attribute labels with an identifying relationship to the referent object (e.g. BANANA or YELLOW were both considered labels associated with the banana).

2.4.1. Coding pointing sequences

We categorized pointing episodes based on the presence and timing of a corresponding object label. Starting with the first point, we identified whether any additional points or corresponding object labels took place within 10 seconds before or after the point. All points and object labels that occurred within 10 seconds were part of the same episode. If there were no object labels within this period, these episodes were considered "point" episodes. Otherwise, pointing episodes with labels were coded as "sequences" and were further categorized into sequence types based on the order of the point(s) and label(s). Each episode continued until there was at least 10 seconds with no points or labels, which marked the end of the episode.

Pointing episodes with labels were further analyzed and coded for sequence success. We considered successful sequences as those in which the child perceived *both* the label and the referent for each sequence. In order to be counted as successful, the child had to perceive the object label by directing gaze to the adult or the adult's hand during production of the sign label, *and* the child had to look at the referent object within 10 seconds of the pointing cue. Time frames

were adapted from previous studies (e.g. Nowakowski et al., 2009, who used a 15 second response window for deaf children to respond to parent cues). If child eye gaze captured only one of the two (object or label), or neither, the sequence was coded as unsuccessful. On sequences with multiple points and object labels, if child eye gaze captured both the label and the referent at least once within the sequence, the sequence was recorded as successful.

3. Results
3.1. Types of pointing sequences

We first sought to identify all of the possible pointing sequences produced by parents to determine how points are timed relative to object labels. In total, we found six types of episodes: isolated points (i.e. those that occurred with no corresponding label), and five unique sequences of points and labels (Figure 1).

POINTING EPISODES WITHOUT LABELS

1. Point

0	Point → Referent	0

POINTING EPISODES WITH LABELS ("SEQUENCES")

2. Label - Point

Label	Point → Referent

3. Point - Label

Point → Referent	Label

4. Label - Point - Label

Label	Point → Referent	Label

5. Point - Label - Point

Point → Referent	Label	Point → Referent

6. Alternating

Point → Referent	Label	Point → Referent	Label

or

Label	Point → Referent	Label	Point → Referent

Figure 1: Categorization of pointing episodes in parent input

Sequences 2 and 3 (label-point and point-label) consisted of a single instance of the label and point. Sequences 4 and 5 (label-point-label and point-label-point) occurred when either the label or point was repeated twice within the ten second window. Sequence 6 (alternating) refers to sequences in which there were multiple instances of *both* the point and the label in varying patterns of alternation.

Across all dyads, there were a total of 513 pointing episodes. Of those, 222 (43%) were isolated points to a referent. These isolated points were present in each dyad, with a range of 1 to 22 occurrences ($M = 9$). These points likely served to direct the child's attention. As there was no accompanying object label, we did not analyze these isolated points further.

The remaining points ($n = 291$) occurred within one of the sequences that included a label (Table 1). The number of sequences by dyad ranged from two to 20 ($M = 12$). The most common sequence was point-label, which accounted for 52% of all sequences.

Table 1: Sequence type distribution for points with labels

Pointing episode	Sequence type	Total number	% of sequences (n=291)
2	Label - Point	45	15%
3	Point - Label	150	52%
4	Label - Point - Label	19	7%
5	Point - Label - Point	27	9%
6	Alternating	50	17%

For each pointing sequence, the label itself was categorized as either a noun label or an attribute label. Noun labels included common nouns for the objects in the toy set (e.g. banana, candle), and attribute labels included concrete features or item specific descriptors (e.g. colors, POUR for gas pump, COOK for oven). Of the 291 pointing sequences, there were 260 sequences containing noun labels and 43 sequences containing attribute labels. If a sequence contained both a noun and attribute label, (e.g. RED STRAWBERRY; RED as the attribute label and STRAWBERRY as the noun label) these were counted as containing both label types. This occurred in 10 sequences.

In summary, parents primarily used points in isolation. When parents produced pointing sequences, they most commonly produced the label after the point (i.e. point-label). Parents used more noun labels than attribute labels in pointing sequences.

3.2. Overall success of pointing sequences

We further analyzed the success of each pointing sequence that contained a label by looking at child gaze during the sequence. Successful sequences were those in which the child was looking at the adult's face or hands during label production, *and* at the referent object within 10 seconds of the point. Across all dyads, the overall success rate of pointing sequences was 61%. We then compared the mean success rate for each sequence to determine whether some sequences were more successful than others. Success rates by sequence type ranged from 53% to 74%. The label-point-label sequence had the highest mean success rate (74%), though this was the least frequent sequence type in the data set. The alternating sequence had the second highest mean success rate (68%), followed by point-label (61%) and point-label-point (55%). The label-point sequence had the lowest mean success rate (53%).

3.3. Sequence type and success as a function of child and parent factors

We investigated whether there were group differences in sequence frequency and success by child age and parent hearing status, first by visualizing the data and then by performing a statistical analysis to determine whether there were specific predictors of success.

3.3.1. Child age

We first investigated the distribution of sequence types by child age, using a median split to divide children into two groups: younger (age range 9 - 33 months, $M = 24.3$) and older (age range = 34 - 60 months, $M = 47.1$) (Table 2). Parents of older children had more pointing episodes, both with and without labels (younger = 220 total episodes, older = 293 total episodes). The distribution of sequence types was similar across groups.

Table 2: Pointing episode distribution by age group

Pointing episode	Description	Younger (n=12)	Older (n=12)
1	Point	92 (42%)	130 (44%)
2	Label - Point	18 (8%)	28 (10%)
3	Point - Label	68 (31%)	83 (28%)
4	Label - Point - Label	6 (3%)	13 (4%)
5	Point - Label - Point	11 (5%)	16 (5%)
6	Alternating	27 (12%)	23 (8%)
Total		220	293

We then examined age group differences in sequence success rate (Figure 2). There were no significant differences in overall success or success rate on each sequence type, though younger children were slightly less successful on point-label-point sequences. The most successful sequence type was label-point-label for both age groups. Children in the younger age group had the same success rates on the label-point-label sequence and the alternating sequence (67%).
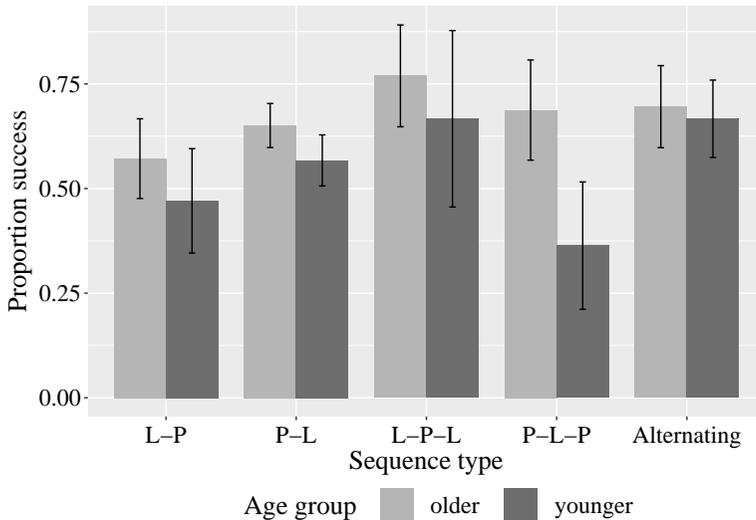

Figure 2: Age groups differences in sequence type success

3.3.2. Parent hearing status

We analyzed the frequency and success of each sequence type used by hearing parents and deaf parents to determine if there were differences based on parent hearing status. There were more deaf parents ($n = 15$) than hearing parents ($n = 9$) in this sample. The distribution of sequence types was similar across groups (Table 3). For both deaf and hearing parents, the most frequent sequence type was point-label and the least frequent sequence types were label-point-label and point-label-point. Deaf parents had a higher overall success rate (65%) than hearing parents (55%). In terms of success with different sequence types, deaf parents showed greater success in using the point-label-point sequence than hearing parents (Figure 3).

Table 3: Sequence type distribution by parent hearing status

Pointing episode	Sequence type	Deaf Parents (n=15)		Hearing parents (n=9)	
		#	Percent of all sequences	#	Percent of all sequences
2	Label - Point	34	17%	12	13%
3	Point - Label	108	53%	43	47%
4	Label - Point - Label	11	5%	8	9%
5	Point - Label - Point	19	9%	8	9%
6	Alternating	30	15%	20	22%
Total		202	100%	91	100%
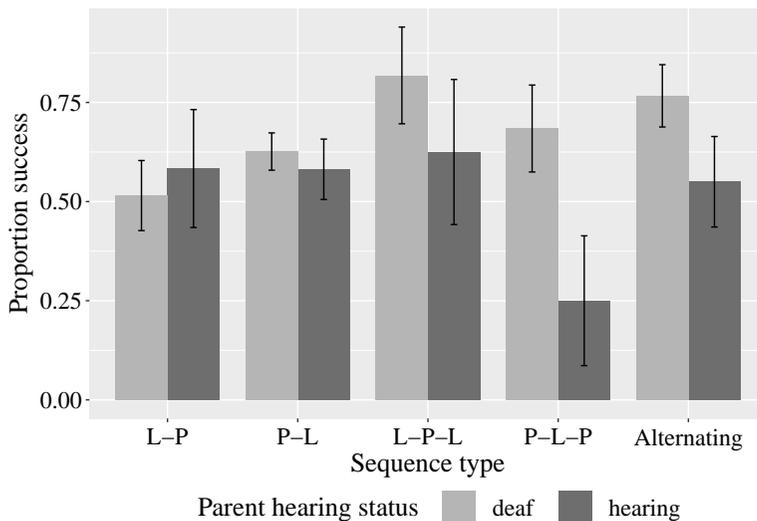
Figure 3: Success of sequences by type and parent hearing status

3.3.3. Statistical analysis

We ran a linear mixed-effects model using the *lmer* package in R to examine whether age and/or sequence type predicted sequence success. Success was the dependent variable, with fixed effects for age, parent hearing status and their interaction, and random effects for participant (Model: Success ~ Sequence_type + Age + Sequence_type * Age + (1 | id)). This analysis revealed no significant

effect of either sequence type or age, and no interaction effect, on sequence success (Table 4).

Table 4: Fixed effects on sequence success

Variable	Estimate	Std. Error	t value
(Intercept)	0.72	0.07	**10.52***
Sequence type	0.03	0.03	0.94
Child age	-0.13	0.10	-1.25
Sequence type X Child age	-0.01	0.05	-0.28

4. Discussion
4.1. Summary of findings

The goal of this study was to offer an initial insight into how parents use pointing as a referential cue to connect labels with objects during interactions with deaf children in ASL. We identified the prevalence and structure of pointing episodes with and without referent labels in parent input, and coded child gaze around these utterances to determine whether they were visually accessible to the child. We found that parents' points occurred most frequently without an accompanying label. When a label occurred in sequence with a point, it most often occurred after the point. The overall success rate of pointing episodes with labels was 61%, with the label-point-label sequence being the most successful sequence type. Though more pointing episodes were found in the older age group, there were no significant differences between younger and older age groups on overall success rate or proportion of each sequence type. There were some differences in sequence success between deaf and hearing parents, with deaf parents showing greater overall success in producing visually accessible pointing sequences, but these differences were not statistically significant.

4.2. Sequence types and success across dyads

Points were most likely to be produced with no accompanying label. Nearly half of the pointing episodes did not contain a referent label. These points most likely served to direct the child's attention, rather than to link the referent object to an ASL label. Our findings align with previous research on maternal input in ASL that found that only about half of utterances that contained a referential point included a referent noun label (Fieldsteel et al., 2020). The present study included both noun and attribute labels, but attribute labels comprised only a small proportion (15%) of all labels within pointing sequences. Points that occur without an accompanying label, serving as attention getting cues during parent-

child interactions, occur across language modalities. Studies of parent-child interactions in spoken language similarly find that the majority of maternal points have the communicative function of directing the child's attention (Rowe, 2000).

When parents produced a label around a pointing cue, the most common placement for the label was after the point (i.e. point-label). This pointing episode was far more frequent than its reverse, label-point. With regard to success, the overall success rate across pointing sequences in parent input was 61%. For a sequence to be successful, the child had to shift gaze to successfully perceive both the label and the referent of the point. Perceiving the label requires mutual gaze with the adult during sign production, as well as following the adult's pointing cue to look at an object. A previous study of mutual gaze among deaf dyads showed that only 22% of the total time spent in parent-child interaction was spent in mutual gaze (Lieberman et al., 2014). The current results suggest that pointing cues are effective attention-getters in parent input for establishing these moments of mutual gaze.

Given the frequency of point-label sequences, it was somewhat surprising that they were only moderately successful. One possible explanation for this pattern is that if the child follows the point to look at the object, they may have difficulty shifting gaze back to the parent in time to catch the label. In contrast, in a label-point sequence, the child may already be gazing towards the parent when the label is produced, but then must disengage from the parent to follow the direction of the point. Interestingly, the label-point-label sequence was the least frequent pointing sequence in parent input, but it had the highest mean success rate. This is an example of a "sandwich" construction that occurs within ASL syntax. In such constructions, a sign can occur in the initial and final position of an utterance to provide emphasis. An example of this construction in the current data set is the utterance "CANDLE POINT(at candle) CANDLE." Producing the label both before and after the point offers two opportunities for the child to shift their attention to the adult and perceive the object label. Prior analysis of children's locus of gaze during play with toys revealed that children spent more time fixating objects than their interactions partner (69% vs. 27%) (Lieberman et al., 2014). Our findings suggest that the label-point-label sequence might be particularly helpful when the child is engaged in play with toys, in which the child may be less likely disengage from the toys to look at the parent.

There were no significant age group differences in the success rate of pointing sequences. It may be that the younger children in our sample were already attuned to parent attention getting cues, like pointing. This would be consistent with Deák et al. (2008), who found that 15-month-old hearing infants are very responsive to pointing cues compared to other attention getting cues. In the current sample, deaf children as young as nine months showed efficient gaze shifting behaviors. This is likely a result of their early exposure to ASL. Infants with early sign exposure show enhanced gaze control relative to hearing infants (Bosworth & Stone, 2021), and are better at following adult gaze than hearing infants (Brooks et al., 2020), critical behaviors for connecting words and objects. The objects used in the play sessions in the current study were all common toys representing objects for which

children likely already had lexical signs. In future research, it will be important to determine whether new signs that are introduced within certain pointing sequences are easier for deaf children to learn than signs produced without accompanying points. We would expect to see age-related differences in children's ability to shift gaze between signs and referent objects in order to learn new words.

The success rate for pointing sequences was slightly higher for dyads with deaf parents than dyads with hearing parents, although the difference was not significant. Deaf parents are likely more familiar with managing attention for communication in a visual modality, and so their interactions may be better structured to help deaf children perceive the both the label and referent during a pointing sequence. Prior research shows that deaf parents have greater success at maintaining deaf children's attention compared to hearing parents (Spencer & Lederberg, 1997; Gale & Schick, 2009). One reason that the success rate was not significantly different among groups is that the hearing parents in our sample were all learning ASL and the children were all exposed to ASL on a regular basis.

4.3. Limitations

Although the sample size in the current study is larger than many previous investigations of parent-deaf child interaction, our findings are still based on a relatively small number of pointing sequences (291 sequences across 24 dyads). In particular, a larger sample size might reveal additional differences in the patterns of sequence use success based on either the age of the child or the parent's experience with ASL. The majority of parents in our sample were deaf, so group differences by parent hearing status should be further analyzed in a more balanced sample. In addition, we chose a time span of ten seconds as our metric for determining whether a referent label occurred in sequence with a point. This time frame was chosen based on previous research and our own observation of the data. Language input is not neatly divided by such time barriers, however, and this brief time window for determining a clear association between objects and their labels and may have masked some instances in which parents were able to support object-referent mapping.

4.4. Study implications

The quantity and quality of parent language input significantly affects children's vocabulary acquisition (Huttenlocher et al., 1991). Examining features of parental input in ASL, such as the association between referential pointing and corresponding object labels, could contribute to identification of optimal strategies for structuring interactions with deaf children so that visual linguistic information is accessible. This is particularly relevant considering that the majority of deaf children are born to hearing parents (Mitchell & Karchmer, 2004) who likely have little experience communicating in the visual modality. Identifying how parents who use ASL incorporate pointing cues into linguistic

input during interaction with deaf children can be informative for hearing parents who decide to learn ASL and may not yet have established strategies for interacting with deaf children and supporting language development. In addition, better understanding visual and referential cues, like pointing, could be informative for early intervention practices for all deaf children. For example, parents could be encouraged to use constructions such as the label-point-label sequence that was highly successful in supporting children's perception of both the object and referent label.

5. Conclusion

Parents use a wide range of temporally organized labels and points in their language input during play interactions with deaf children in ASL. Pointing gestures are salient cues that parents can leverage to scaffold language input in a way that guides children in making the connection between words and their referent objects. Understanding how parents use points within their ASL input to structure interactions with deaf children informs our knowledge of the nature of dyadic communication when all information is perceived visually.

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