UC Merced

Proceedings of the Annual Meeting of the Cognitive Science Society

Title

Exploring Joint Attention in American Sign Language: The Influence of Sign Familiarity

Permalink

https://escholarship.org/uc/item/5kq2s523

Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 45(45)

Authors

Sander, Jennifer
Lieberman, Amy
Rowland, Caroline F

Publication Date

2023

Peer reviewed

Exploring Joint Attention in American Sign Language: The Influence of Sign Familiarity

Jennifer Sander (Jennifer.Sander@mpi.nl)
Max Planck Institute for Psycholinguistics, Wundtlaan 1, 6525XD Nijmegen, The Netherlands
Max Planck School of Cognition, Stephanstr. 1A, 04103 Leipzig, Germany

Amy M. Lieberman (alieber@bu.edu)
Wheelock College of Education & Human Development, Two Silber Way, Boston, MA 02215 USA

Caroline Rowland (Caroline.Rowland@mpi.nl)
Max Planck Institute for Psycholinguistics Wundtlaan 1, 6525XD Nijmegen, The Netherlands
Donders Institute for Brain, Cognition and Behaviour, Radboud University,
Thomas von Aquinostraat 4, 6525 GD, Nijmegen, The Netherlands

Abstract

Children's ability to share attention with another social partner (i.e., joint attention) has been found to support language development. Despite the large amount of research examining the effects of joint attention on language in hearing population, little is known about how deaf children learning sign languages achieve joint attention with their caregivers during natural social interaction and how caregivers provide and scaffold learning opportunities for their children. The present study investigates the properties and timing of joint attention surrounding familiar and novel naming events and their relationship to children's vocabulary. Naturalistic play sessions of caretaker-child-dyads using American Sign Language were analyzed in regards to naming events of either familiar or novel object labeling events and the surrounding joint attention events. We observed that most naming events took place in the context of a successful joint attention event and that sign familiarity was related to the timing of naming events within the joint attention events. Our results suggest that caregivers are highly sensitive to their child's visual attention in interactions and modulate joint attention differently in the context of naming events of familiar vs. novel object labels.

Keywords: Joint Attention; Language Acquisition; ASL; Sign Language; Sign Familiarity; Language Modality

Introduction

Joint attention (JA), broadly defined, describes the active, shared coordinated attention of a child and a caregiver on an object or an event (Gabouer & Bortfeld, 2021). It is a crucial social-communicative skill involved in language acquisition and social interaction. Engaging in JA has been shown to facilitate word learning in infants and young children and the amount and quality of JA in which children are engaged correlates with subsequent vocabulary development (Abney et al., 2020; Morales et al., 2000; Yu, Suanda & Smith, 2019). However, most studies on JA in language acquisition focus on hearing children using spoken languages and most theories about JA also only consider the spoken modality. The consequence is that the parallel perception of an object of interest through the visual modality and a corresponding object label through the auditory modality has been assumed to be an essential characteristic of JA. In contrast, interactions with deaf children using sign languages such as American Sign Language (ASL) occur in a more sequential manner. Language input and objects of interest are both perceived visually, so signers' visual attention must be divided between an object of interest and the corresponding language input. Due to the visual nature of sign language input, studies on JA in sign languages find differences in dyadic interactions based on language modality. Specifically, dyads interacting in sign language engage significantly more often in mutual gaze, show higher rates of gaze switches and shorter bounds of sustained attention than dyads interacting in spoken language (Gale & Schick, 2008; Lieberman, Hatrak & Mayberry, 2014). These differences suggest that JA looks different, has different characteristics, and may function differently in signing dyads.

While the relationship between JA and language acquisition is well established, the mechanisms through which JA supports children's ability to learn words are not fully established. Several studies suggest that JA supports label-object mapping because the mapping of labels to their referents are more explicit during JA. In addition, the amount, length, and quality of JA is correlated with faster and larger vocabulary growth (e.g. Yu et al, 2019). The fact that JA is particularly important in word learning suggests that the nature of JA episodes might differ based on the familiarity of the object being labeled. That is, parents may be particularly sensitive to moments of JA when labeling novel objects as compared to familiar objects, because the label-object mapping is critical to word learning. While studies have investigated the influence of JA on children's novel word learning abilities (e.g. Hirotani et al., 2009 in regards of ERPs in novel word learning in JA), the quality or quantity of JA with familiar vs. novel objects and object labels has not been directly compared. Further, we do not yet know which of the properties of JA have an effect on children's language acquisition or how these differ under different conditions (e.g. familiar vs. novel object naming events). For example, is it the frequency of JA events, or their duration, that predicts later language outcome? Does JA have different

characteristics under different conditions? Does JA look different, depending on the familiarity of an object of interest or the corresponding naming event?

The goal of the present study is to investigate the characteristics of JA episodes in dyads with deaf children using ASL. We compare JA events surrounding familiar vs novel object naming events and the potentially differing influence of these characteristics of JA on language learning.

Current Study

The goal of the current study was to investigate timing and properties of JA episodes in caregiver-deaf child dyads who are using ASL. Children interacting in ASL must be directing their attention towards their caregiver in order to perceive an object label, thus it is likely that parents choose particular strategies to gain and maintain the child's attention suitable for the way interactions take place in ASL. Using a dataset of samples of naturalistic play between caregivers and deaf children we identified naming events in continuous interaction and asked whether the familiarity of an object being labelled affects the way in which JA is structured in ASL. We compared JA around familiar vs novel object naming events to address the following questions:

1. **Naming Events and how they are aligned with Joint Attention Events:** how often do naming events occur in the context of JA events?
2. **Exploration of the properties of JA Events around Naming Events:** do the properties of JA events surrounding naming events vary depending on the familiarity of the sign / object?
3. **Caregivers' attentional strategies around JA Events surrounding Naming Events:** do caregivers adjust their attentional strategies to establish JA depending on the familiarity of the object being labelled?
4. **Effects of JA on children's ASL vocabulary**: are different JA strategies used by caregivers equally successful in facilitating ASL development in deaf children?

We predicted that caregivers might be intentional about initiating and timing JA events to ensure that visual attention is established prior to naming an object in ASL. We further predicted that this might be especially true for novel object labels, in which the child's gaze to the caregiver during labelling is critical to the child's ability to learn the novel label and map it to the referent.

Method

Participants

Participants were 54 parent-deaf child dyads whose primary language was American Sign Language (ASL). Children were between the age of 9 months and 69 months (M=38.6, SD=14.2). All children were either deaf or hard of hearing. Parents were deaf (n = 44) or hearing (n = 10) and all reported

using ASL with their deaf child. Participants represent a subset of dyads from a corpus of parent-child interactions in ASL previously collected by the second author, the ASL-PLAY dataset (https://osf.io/3w8ka/). Some dyads participated in multiple sessions; the first recording of dyads with more than one session was selected for this analysis.

Experimental Setup

Children played with a caregiver in a naturalistic play situation. Dyads participated in one of two types of play sessions. In *familiar* play sessions (n=23, M=35 m.o.), dyads were given a set of familiar objects (e.g. an animal set, a toy fruit set, a train set). In *novel* play sessions (n=31, M=41 m.o.), dyads were given both familiar objects as well as four novel objects: two animals (ostrich, armadillo) and two fruits (kiwi, dragonfruit). Signs for these four objects (that do not have a lexical sign in ASL) were borrowed from other sign languages and introduced to the caregivers in advance so that caregivers could use the novel sign if interacting with the object during the play sessions. Caregivers were instructed to play with their child as they typically would; in the novel sessions, caregivers were also instructed to use the provided sign labels for the novel objects when they encountered them. Play sessions lasted between 12 and 15 minutes and were video-recorded from three different angles.

Data Processing

Data was processed and annotated in the video analysis program ELAN (Version 6.4; MPI for Psycholinguistics, The Language Archive, 2022). Based on annotations of ASL production, we identified a set of "naming events" in each interaction. A naming event was defined as production of an ASL sign referring to an object by either the caregiver or child. In the familiar condition, we identified all naming events that referred to a concrete object. In the novel condition, we identified all naming events that referred to one of the four novel objects. Based on previous annotations of gaze, touch, ASL signs, and different attentional behaviours, we annotated instances of JA surrounding relevant (familiar or novel) naming events. We applied the Gabouer and Bortfeld (2021) coding scheme for JA. This coding scheme represents a flexible modality-independent approach to identify episodes of JA in dyadic interactions. The coding scheme allows us to differentiate between successful and unsuccessful JA events, particularly successful and unsuccessful attempts at initiating JA, and the potentially resulting JA episodes. In line with the Gabouer & Bortfeld coding scheme, a successful JA event between two interaction partners is described as a sequence consisting of 1) an initiator's bid for attention; 2) a target's response to the initiation bid; and 3) an initiator's verification of the target response. All three parts of the sequence must be present and in a specific temporal relationship to each other to be considered a successful JA episode. A number of different behaviours can be coded as initiation, target response, and verification (touch, gaze, language usage, other behaviours),

as long as the behaviours are directed either at the object of shared interest or the interaction partner.

We applied the JA coding scheme to identify all JA events surrounding familiar or novel naming events, depending on familiarity condition. We then identified different meaningful properties of JA from the coding scheme that would allow us to investigate the temporal structure of JA and the role of the interaction partners. JA events surrounding naming events represent a subset of all JA events within an interaction, namely the JA events that lead to a naming event. Thus, the properties and characteristics of JA events we report on are not the characteristics of JA events in general, but specifically those in which context caregivers choose to label objects with a familiar or novel sign.

At the time of testing, children's concurrent ASL vocabulary was assessed through a parental questionnaire, the ASL-CDI 2.0 (Caselli, Lieberman & Pyers, 2020), which is an adaptation of the Mac-Arthur-Bates Communicative Development Inventory (CDI). Production as well as comprehension scores were calculated as a proportion known of all items to which parents provided a response.

Results

Naming Events and how they are aligned with Joint Attention Events

All analyses were conducted in R-Studio version 4.1.2. (R Core Team, 2021). There were, in total, 882 naming events that occurred within 521 JA events (some JA events contained multiple naming events due to repeated labels of the same object within a single JA event). In the familiar condition, there were 496 naming events that occurred within 335 JA events. In the novel condition, there were 386 naming events that occurred within 186 JA events (Table 1).

We considered each relevant naming event as at least an attempt to initiate JA, which resulted in two possible interactional environments for each naming event: 1) They were part of a longer, successful JA event, or 2) they were part of an unsuccessful JA event which did not fulfill all requirements to be considered successful. We calculated the proportion of naming events that occurred within successful JA events. Of the 882 naming events, 81.83% (721 naming events) were part of a successful JA event and only 18.16% (161 naming events) were part of an unsuccessful JA event. We can conclude that most naming events occur in the environment of a (mostly successful) JA event and only in a small number of cases they are part of an unsuccessful JA initiation. These naming events coupled with JA events provide children with multifaceted learning opportunities, by offering the object label in direct interaction with the object. Based on the observation that most naming events are surrounded by (successful) JA events, we were interested in the properties of JA events and how they potentially differ depending on the familiarity of the object label.

Table 1: Overview Naming and JA Events

Condition	Number Naming Events	Number JA Events		
		Successful JA Event	Unsuccessful JA Event	Total
Familiar	496	230	105	**335**
Novel	386	148	38	**186**
Total	**882**	**378**	**143**	**521**

Exploration of the properties of JA Events around Naming Events

We explored a number of properties of the JA events involving a naming event, comparing the two sign familiarity conditions. First, we compared the mean duration, and second, the frequency, of initiation per interaction partner (caregiver or child) across familiar/novel context. Overall, JA events had a mean duration of 13.25 seconds and 84% of these JA events were initiated by the caretaker and the remaining 16% by the child of the dyad. We conducted a linear regression to analyze the effects of sign familiarity. We did not find significant effects of sign familiarity on either mean JA event duration (Figure 1, model: mean JA event Duration ~ Sign Familiarity, $\beta=0.41$, SE=4.12, t=0.1, p=0.92) or JA initiation rate of the interaction partners (Figure 2, model: Initiation Rate Parent-Child ~ Sign Familiarity, $\beta=0.089$, SE=0.13, t=0.7, p=0.49). In JA events around both familiar and novel objects, caregivers are the primary initiators, and the duration of the JA events does not differ by object familiarity.
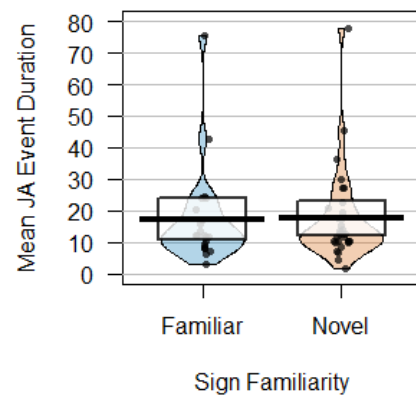

Figure 1 Mean duration of JA events per dyad by sign familiarity. Points represent raw data. Bean shows smoothed density curve illustrating the full data distribution. Error bars show frequentist confidence interval.
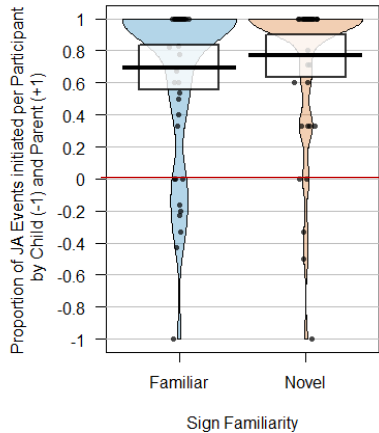
Figure 2 JA Event Initiation Rate per Participant, by Child (-1) or Parent (+1), by sign Familiarity. Points represent raw data. Bean shows smoothed density curve showing the full data distribution. Error bars show frequentist confidence interval. Red line represents equal initiation rate.

Caregivers' attentional strategies around JA Events surrounding Naming Events

We investigated caregivers' attentional strategies, and possible effects of sign familiarity on those. First, we investigated the effect of sign familiarity on the average JA event success rate per dyad. There were more successful JA events in the novel than the familiar naming contexts (Figure 3, model: Success ~ Sign Familiarity, β=0.11, SE= 0.06, t=1.89, p=0.065).

Recall that a successful JA event occurred when all three elements of the JA event were present (initiation, response, verification). As the initiation is the first element of a JA event and hence the crucial bid for attention, we were particularly interested in how caregivers enacted initiations based on sign familiarity. JA was initiated using a range of visual and/or tactual behaviours including ASL signs, tapping the child, waving, using objects, or shifting gaze. Several behaviours can occur at the same time, as behaviours can be combined and rarely appear in a strictly sequential manner. To account for this, we asked how often an object label / naming event occurred during the JA initiation. We were interested to see whether it depends on sign familiarity if a label itself might serve as (part of) the initiation to JA, or if caregivers might use a more overt behaviour to first establish attention, and then product the naming event once the child had responded to the bid. We used a linear regression to analyze how sign familiarity affected the location of the naming event. We found that naming events were significantly more often part of the JA initiation in the familiar than in the novel condition (Figure 4, model: Naming Event during Initiation ~ Sign Familiarity, β=-0.22, SE=0.06, t=-3.80, p= 0.00037). In fact, while a naming event occurred during JA Initiation 36% of the time in the familiar condition, this occurred only 14% of the time in the novel condition. If we assess only the cases where the naming event was the initiating behaviour itself and not just occurring during the initiation, the numbers are even more striking: while familiar

naming events make up 30% of JA initiations in the familiar condition, novel naming events make up only 8.7% in the novel condition. This aligns with our prediction that caregivers are sensitive to the locus of child attention prior to naming an object, particularly when that object is new to the child.

Based on this observation that novel naming events are less likely to be part of the JA initiation, we were interested in the timing of the first naming event within the JA event. If we look at the timing of the first naming event within each JA event, we do not find a significant effect of sign familiarity (Figure 5). Overall, even though naming events are less often part of the initiation, they occur similarly early within the JA event, within the first few seconds of the shared attention (model: mean temporal lag between JA onset and first naming event ~ Sign Familiarity, β=-0.35, SE=1.28, t=-0.28, p= 0.79). Naming events, independent of their familiarity, occurred on average 4.53 seconds after the onset of the JA event's shared attention.

Finally, we compared the number of naming events per JA event (Figure 6). There were significantly more naming events (repetition of the label) per JA event in the novel than the familiar condition (model: mean number of Naming Events per JA Event ~ Sign Familiarity, β=-0.69, SE=0.19, t=3.62, p= 0.00066). In other words, caregivers repeated novel labels more during JA events than familiar labels.
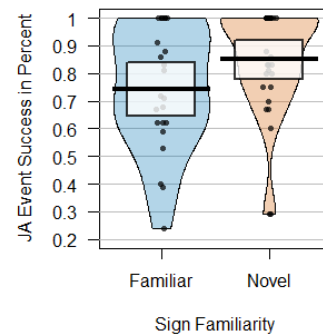

Figure 3 Mean JA event success rate per dyad in percent by sign familiarity. Points represent raw data. Bean shows smoothed density curve illustrating the full data distribution. Error bars show frequentist confidence interval.
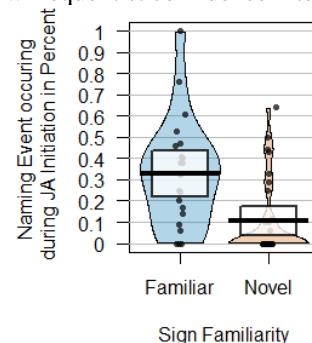

Figure 4 Proportion of naming events occurring during JA event initiation by sign familiarity. Points represent raw data. Bean shows smoothed density curve illustrating the full data distribution. Error bars show frequentist confidence interval.
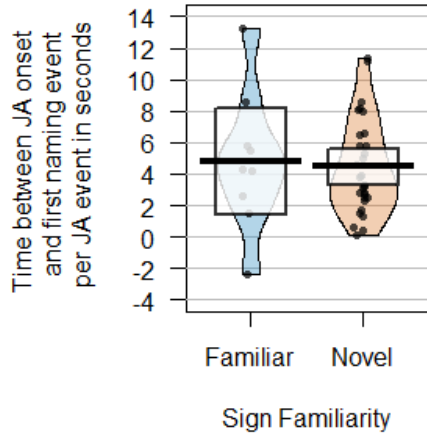
Figure 5 Mean time between the onset of the JA event and the onset of the first naming event of the JA event in seconds. Positive values mean that the naming event occurred after shared attention has been established, while negative values represent a naming event occurring before shared attention has been established, e.g. during the JA event initiation. Points represent raw data. Bean shows smoothed density curve illustrating the full data distribution. Error bars show frequentist confidence interval.
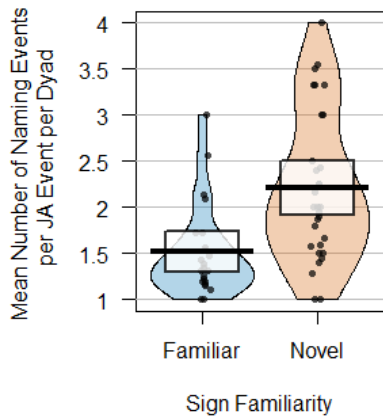

Figure 6 Mean number of naming events (repetition) per JA event by sign familiarity. Points represent raw data. Bean shows smoothed density curve illustrating the full data distribution. Error bars show frequentist confidence interval.

Effects of JA on children's ASL vocabulary

The amount and quality of JA is correlated with child language among hearing children learning spoken language. We predicted that a parallel relationship would exist among deaf children learning ASL. We analyzed the relationship between the duration and success of JA events and the children's concurrent vocabulary size (ASL comprehension and production vocabularies using ASL-CDI 2.0 scores). A regression model showed a significant positive effect of mean JA success rate per dyad on production (model: production vocabulary ~ JA Success rate * Sign Familiarity, β= 0.81, SE=0.25, t=3.24, p= 0.0028) as well as comprehension vocabulary (model: comprehension vocabulary ~ JA Success rate * Sign Familiarity, β= 0.36, SE=0.10, t=3.79, p=

0.00063), though no significant effect of sign familiarity nor any interaction effect between mean JA success rate and familiarity. Children in dyads with higher average JA success rates had significantly higher concurrent ASL vocabulary scores in both production and comprehension (Figure 7). There was also a significant positive effect of mean JA duration on production (model: production vocabulary ~ mean JA Event Duration* Sign Familiarity, β= 0.0082, SE=0.0033, t=2.47, p= 0.019) but not comprehension CDI scores (model: comprehension vocabulary ~ JA Success rate * Sign Familiarity, β= 0.0027, SE=0.0014, t=1.95, p= 0.06), with no effect of sign familiarity on either CDI scores nor an interaction effect (Figure 9). Children in dyads with longer mean JA durations had significantly higher concurrent ASL expressive vocabulary scores.
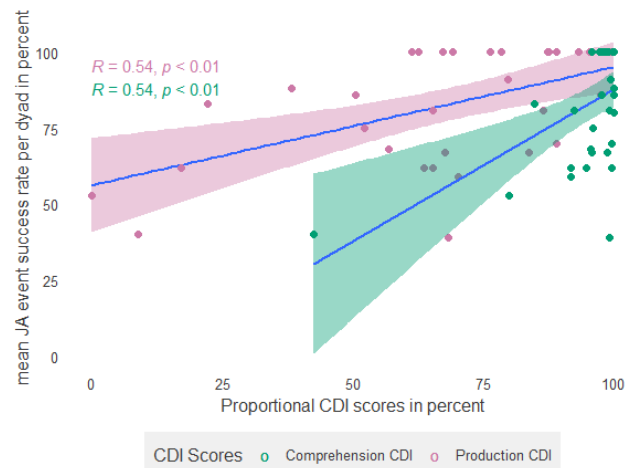

Figure 7 Relationship between mean JA success rate per dyad and proportional production and comprehension CDI scores. Lines shows regression line, shading reflects 95% confidence interval, dots show scores for individual children.
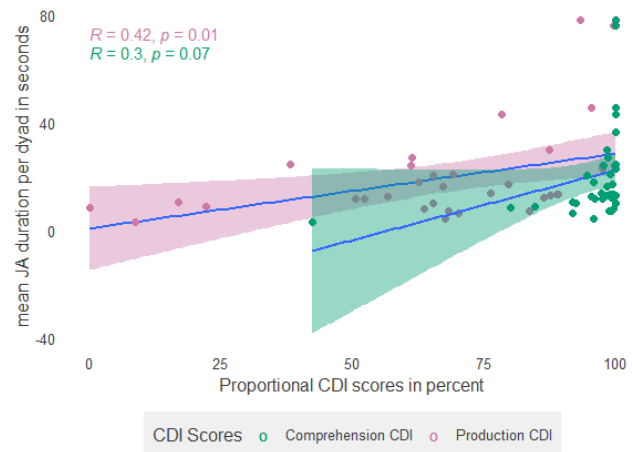

Figure 8 Relationship between mean JA duration per dyad and proportional production and comprehension CDI scores. Lines shows regression line, shading reflects 95% confidence interval, dots show scores for individual children.

Discussion

The goal of this study was to explore the interactional environment of familiar vs novel naming events in caregiver-deaf child dyads communicating in ASL. We examined the duration, success, and type of initiation of JA events around familiar and novel object labels to investigate characteristics of JA events surrounding naming events and to determine whether caregivers structure JA events differently based on the familiarity of the object being labeled. Our main findings were as follows: overall, most naming events occurred in the environment of a (successful) JA event. Across conditions, JA events surrounding a naming event were most frequently initiated by the parent rather than the child. The number of initiation attempts and the duration of JA events were similar across familiar and novel object labels. There were some differences in JA events by condition: JA events surrounding novel naming events were equally successful than those surrounding familiar naming events. Meanwhile, there were more naming events during JA initiation in the novel than in the familiar condition. Interestingly though, there was no significant difference in the timing of when the first naming event occurred within the JA event between the two conditions. In addition, even though the average duration of JA events did not differ between familiar and novel naming events, the average number of naming events per JA event is significantly higher for novel than familiar naming events. Caregivers were thus more likely to repeat a novel label than a familiar label during a JA event. We found properties of JA events to be correlated with the concurrent ASL language abilities of the child. This is in line with findings on the general relationship between JA and child vocabulary among hearing children learning spoken language (e.g. Abney et al., 2020; Morales et al., 2000; Tomasello & Farrar, 1986). Average dyadic JA success rate was positively related to the child's expressive vocabulary score, while mean JA duration per dyad was positively related to the child's expressive but not receptive vocabulary scores. The correlations with vocabulary were similar across conditions, and vocabulary did not have a moderation effect on either JA success rate nor mean JA duration.

A major difference between interactions in sign language and spoken language is the sequentiality of the signals. When using sign language, caregivers have to acquire the child's visual attention before labelling an object if they want to ensure that the child does not miss it. In contract, in spoken interactions, an object label can be successfully perceived by a child even if the visual attention is not on the caregivers, though multimodal cues certainly support spoken language learning (e.g. Özyürek et al., 2008). As a result, caregivers have to exhibit a high sensitivity to their child's current locus of attention, which could directly affect caregiver's behaviours in JA events. Our findings suggest that dyads might follow different joint attentional strategies, depending on whether the object attended to has a familiar or novel label. Sign familiarity affected the timing of naming events and the number of times a label was repeated during a JA event. Caregivers may have been intentional in providing multiple instances of labels for novel objects to support word learning. In particular, familiar signs seem to be more often used as an attention getting behaviour to initiate JA events than novel signs, while novel sign naming events are much more likely to occur only after JA initiation. In the context of novel naming events, JA is much more likely to be initiated by other attention getting behaviours, such as waving, tapping, gaze or object touch. This suggests that caregivers are sensitive to the (assumed) familiarity or novelty of a sign and seem to time naming events correspondingly differently, presumably to ensure that the child is attending to them to maximise the chances for the child to successfully match the sign to the intended referent.

The results of this study have important implications for our understanding of how dyads generally navigate JA events when using ASL. Overall, we have observed that some general characteristics of JA events have not been affected by the sign's familiarity (like mean duration of JA event or initiation rate per interaction partner). Other characteristics of the JA events, such as the number of naming events per JA event, do exhibit effects of sign familiarity, in the sense that caregivers seem to show awareness of the (assumed) novelty. This provides an interesting view on JA events surrounding naming events: interactions surrounding naming events in dyadic play situations seem to follow the rhythmic dyadic pattern of JA (rhythmic interactions are a common pattern in interactions across species and modality as suggested by e.g. Reus et al., 2021). Those instances of JA appear to be flexible enough to allow variation around different conditions, as in this study in regards to the familiarity of labels, but steady enough to not be affected in its general properties, at least in the continuation of maintenance of the foundational rhythm. Our results suggest not only that caregivers are sensitive to sign familiarity, but that both dyad partners, caregivers as well as children, are highly sensitive to one another's interactional (visual) cues, particularly when labelling objects during play. The vast majority of naming events (familiar and novel) were surrounded by a successful JA event, meaning that the dyad has successfully maneuvered through the three steps of a JA interaction. This is only possible if both caregiver and child are highly attentive to the attentional, visual cues of their interaction partner. Modality of interaction shapes the nature of JA, and within the visual modality, the structure of JA varies according to whether there are opportunities for word learning within the episode.

The observations made in this study give us a better understanding of if, and how, caregivers shape the interactional environment in which children encounter labels to the objects in their surroundings. Investigating how the properties of JA events vary under different conditions and between modalities offers insight into broader questions about how approaches to JA by caregiver and child may adapt to the environment and to the sensory modal needs of the language learner. Our study contributes to our understanding of the importance of JA as a special type of interaction that supports early language learning across modalities.

References

Abney, D. H., Suanda, S. H., Smith, L. B., & Yu, C. (2020). What are the building blocks of parent-infant coordinated attention in free-flowing interaction? *Infancy, 25(6),* 871-887.

Caselli, N. K., Lieberman, A. M., & Pyers, J. E. (2020). The ASL-CDI 2.0: An updated, normed adaptation of the MacArthur Bates Communicative Development Inventory for American Sign Language. *Behavior Research Methods, 52*, 2071-2084.

Gabouer, A., & Bortfeld, H. (2021). Revisiting how we operationalize joint attention. *Infant Behavior and Development,* 63, 101566.

Gale, E., & Schick, B. (2008). Symbol-infused joint attention and language use in mothers with deaf and hearing toddlers. *American Annals of the Deaf, 153(5)*, 484-503.

Hirotani, M., Stets, M., Striano, T., & Friederici, A. D. (2009). Joint attention helps infants learn new words: event-related potential evidence. *NeuroReport, 20(6),* 600-605.

Lieberman, A. M., Hatrak, M., & Mayberry, R. I. (2014). Learning to Look for Language: Development of Joint Attention in Young Deaf Children. *Language Learning and Development, 10(1)*, 19-35.

Max Planck Institute for Psycholinguistics Nijmegen, The Language Archive (2022). *ELAN* (Version 6.4). Retrieved from https://archive.mpi.nl/tla/elan

Morales, M., Mundy, P., Delgado, C. E. F., Yale, M., Messinger, D., Neal, R., & Schwartz, H. K. (2000). Responding to Joint Attention Across the 6-Through 24-Month Age Period and Early Language Acquisition. *Journal of Applied Developmental Psychology, 21(3)*, 283-298.

Özyürek, A., Kita, S., Allen, S., Brown, A., Furman, R., & Ishizuka, T. (2008). Development of cross-linguistic variation in speech and gesture: Motion events in English and Turkish. *Developmental Psychology, 44(4),* 1040-1054.

de Reus, K., Soma, M., Anichini, M., Gamba, M., de Heer Kloots, M., Lense, M., Hyland Bruno, J., Trainor, L., & Ravignani, A. (2021). Rhythm in dyadic interactions. *Philosophical Transactions of the Royal Society B, 376.*

RStudio Team (2020). *RStudio: Integrated Development for R. RStudio, PBC, Boston, MA*. https://rstudio.com/.

Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child development*, 1454-1463.

Yu, C., Suanda, S. H., & Smith, L. B. (2019). Infant sustained attention but not joint attention to objects at 9 months predicts vocabulary at 12 and 15 months. *Developmental Science, 22(1).*