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Studying Sign Language Acquisition

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Summary Box: The study of sign language acquisition has revealed important insights regarding the acquisition of language in the visual modality, the impact of delayed first language exposure on language ability, and the relationship between language and cognitive processes. Unique challenges arise in studying sign language acquisition due to the low incidence and heterogeneity of the population, and the need for inclusion of highly skilled, native and near-native language users who are deaf in all aspects of the research. Despite these challenges, a range of methodological approaches have been applied to sign language acquisition, including longitudinal and cross-sectional sampling of the population, case studies, adaptation of assessment instruments, standardized measures, analyses of naturalistic language and elicited language samples. Through these methods, researchers are able to conduct rigorous studies whose findings have made invaluable contributions to theories of language acquisition and development in a number of sign languages and populations.

Introduction: Key questions motivating sign language acquisition research

The field of language acquisition has a long and fertile history beginning with diary entries of researchers' children (e.g. Preyer, 1889; Tomasello, 1992), extending to large-scale studies designed to garner generalizations about how children talk as they grow (Templin, 1957), and to studies and experiments aimed at teasing apart how children master a given language structure or cognitive phenomenon (Bloom, 1970; Brown, 1973). The more recent field of sign language acquisition research asks similar questions using similar methods but with a complicating overlay of issues. These issues include the possible effects of sensory-motor modality on language acquisition, i.e. whether the acquisition of visual-manual languages looks

similar to or different from that of auditory-oral languages. Then there are the *a priori* issues of whether and how the age of onset of language acquisition and the amount and quality of language input affect the trajectory and outcome of this universal process of child development. Understanding sign language acquisition is also essential to educators and clinicians who work with deaf children, as well as other populations, but here we focus primarily on the key questions researchers have asked about sign language acquisition and how they have gone about answering them.

A fundamental question motivating sign language research is this: how is sign language acquisition similar to and/or different from spoken language acquisition? Typically this question is asked assuming that the circumstances surrounding acquisition of the two kinds of language are parallel, i.e., that language is acquired in the typical untutored fashion from birth in an environment in which the parents are proficient users of the language and primary transmitters of the language to their children (Mayberry & Squires, 2006). Thus the underlying question becomes what — if any — differences arise in the processes and content of language acquisition as a result of the fact that it is produced manually and perceived visually. Assuming that spoken and signed language acquisition are not identical, and that some modality-based differences exist, a related question asks what studies of sign language acquisition reveal about language, modality, and acquisition in general. These questions address the extent to which the learning processes that underlie language acquisition are supramodal in nature.

The study of sign acquisition has led to lively discussion regarding the visuo-spatial nature of sign language and its potential effects on acquisition. For example, studies of the timing of the onset of first sign production have sought to determine whether first signs appear before first spoken words; evidence suggests that there is little if any difference in the onset of

the two kinds of language, and any difference is short-lived (Meier & Newport, 1990; Anderson & Reilly, 2002). Studies of complex morphological structures such as classifiers have contributed to theoretical perspectives regarding the nature of sign vs. gesture, the role of iconicity in acquisition (Thompson, Vinson, Woll, & Vigliocco, 2012), and the degree to which children perceive and acquire such structures holistically or as multi-unit combinations (Schick, 1990; Slobin, Hoiting et al., 2003). Underlying all these debates is the question of what constitutes word learning and how it can be distinguished from gesture. The need to think deeply about this issue arises from the fact that language and gesture occur within the same modality when language is signed but are expressed cross-modally when language is spoken.

One particular factor in language acquisition hypothesized to be impacted by modality is the nature of parent-child interactions. Specifically, given the highly visual nature of joint attention interactions in early parent-child communication, researchers have explored the ability of deaf and hearing parents to obtain and maintain joint attention with their young deaf children. This is typically approached through naturalistic observations of dyadic interaction between caregivers and their children, which are videotaped and later coded and analyzed for specific features including eye gaze, attention getting, and joint focus on objects. In studies of how deaf parents sign to their deaf children, research encompassing several different sign languages has identified a visual equivalent to child-directed speech, known as child-directed signing (Erting, Prezioso, & O'Grady Hynes, 1990; Holzrichter & Meier, 2000; Masataka, 1992). This sign language register includes many parallels to child-directed speech, including a slower rate of signing, greater repetition, shorter utterances, larger signs, and positive facial affect. In addition, deaf parents have been shown to make modifications in their signing in order to make signs more visually accessible to deaf children, including the use of overt attention-getters, moving objects

into the child's line of vision, signing on objects, or signing on the child's body (Spencer, Bodner-Johnson, & Gutfreund, 1992; Harris, Clibbens, Chasin, & Tibbitts, 1989; Masataka, 1992; 2000). Deaf children also exhibit a developing ability to alternate gaze between their mother and an object or book of interest, and they have sophisticated abilities to do so from an early age provided they are exposed to sign language from birth (Lieberman, Hatrak, & Mayberry, 2014).

Beyond the question of modality, one of the unique characteristics of sign language learners in comparison to spoken language learners is the degree to which they vary in the age of first language exposure. A very small proportion (roughly 5-10%) of deaf children have deaf parents and thus are exposed to sign language from birth (Mitchell & Karchmer, 2004). The remaining 90-95% of deaf children have hearing parents with no prior experience with deafness or sign language, thus language acquisition among these children follows a large range of alternative trajectories. The introduction of universal newborn hearing screening has decreased the age at which hearing loss is typically identified in many developed countries. However, even with early identification, deaf children who are born to hearing parents are first exposed to sign language at ages ranging from birth to adolescence (and some deaf individuals are never exposed to sign language). For these children, and specifically the ones who have insufficient access to spoken language to acquire it as a functional language, sign language becomes, *prima facie*, their first language. In this sense the population of deaf individuals presents a unique opportunity for researchers to study the effects of delayed first language acquisition, the relationship between age of acquisition (AoA) and language ability across domains, and the relationship between language proficiency and specific cognitive abilities including theory of mind, executive function, working memory, and brain-language processing.

The impact of delayed first language acquisition on later language ability and cognitive skills cannot be investigated through studies of spoken language acquisition because, except in extreme cases of neglect or abuse, hearing children are universally exposed to at least one language from the time they are born. In contrast, through studies of deaf individuals who acquired their first language in early or late childhood or even in adolescence, we have learned that if a first language is not acquired during the critical or sensitive period, there are lasting differences in both receptive language processing and productive language proficiency (Mayberry & Eichen, 1991; Newport, 1990). In these studies, acquisition is studied retrospectively by observing deaf adults who vary based on their age of first language exposure. For example, in an experiment involving sentence repetition, native signers tended to make more errors at the semantic level, while late learners tended to make more phonologically based errors, suggesting that late learners expend more cognitive resources on the perceptual and word recognition stages of language processing than native or early learners (Mayberry & Eichen, 1991). These differences between native learners and late-learners persist even after years of experience with sign language, indicating that it is the age of first language exposure, not the amount of language experience, that leads to these deficiencies. Further, these differences do *not* appear in deaf or hearing individuals who learn sign language as a second language, confirming that it is the age of first language exposure that leads to these critical differences (Cormier, Schembri, Vinson, & Orfanidou, 2012; Mayberry, 1993; Mayberry, Lock, & Kazmi, 2002). In ongoing research we are now using both a developmental and retrospective paradigm to investigate the neural correlates of these effects of delayed first language learning (Mayberry, Chen, Witcher, & Klein, 2011; Ferjan Ramirez, Leonard, Torres, Hatrak, Halgren, & Mayberry, 2013; Leonard, Ferjan Ramirez, Torres, Travis, Hatrak, Mayberry, & Halgren, 2012).

A third branch of inquiry in sign language acquisition has grown from the fact that many deaf children learn sign language from a range of models other than their parents, and some are not exposed to sign language at all. This atypical situation has led to research on the nature of language acquisition in the absence of typical input. Work by Goldin-Meadow and colleagues, using analyses of naturalistic samples of child and mother communication elicited under controlled conditions (such as providing the same set of toys and books for each participant), has shown that deaf children without adult sign language input develop a system for communication that contains linguistic structure at multiple levels, often referred to as homesign (Goldin-Meadow & Mylander, 1998). A growing body of work on an emerging sign language among several school-based generations of deaf individuals in Nicaragua has revealed additional insights. In this population, important differences have been identified in the grammatical structure and cognitive sophistication of the language of children based on whether they were in the first, second, or subsequent cohorts of individuals exposed to a new sign language, with each cohort's language use becoming more linguistically structured (Senghas & Coppola, 2001). Similar to studies of sign and spoken language acquisition, these studies elicit spontaneous sign language samples using a variety of stimuli, including descriptions of filmed events and still pictures. Data from homesigners continues to provide insights into the features of gestural communication in the absence of sign language input, particularly in countries in which there is not widespread access to formal education for deaf individuals (Coppola & Newport, 2005).

Finally, due to the increasing tendency for deaf children to receive cochlear implants from an early age, research has led to important findings about the potential benefits of early sign language exposure on spoken language acquisition (Hassanzadeh, 2012). Despite increasing pressure placed on families with deaf children to use an oral-only approach following cochlear

implantation, research has found no conclusive evidence that the oral-only approach is correlated with improved spoken language outcomes. Given the widely established importance of early language exposure, which holds equally for signed and spoken language, it is imperative that continued scientific research establish the potential benefits of early sign language exposure for all deaf children, regardless of the amount and type of assistive technology from which they can benefit (Davidson, Lillo-Martin, & Chen Pichler, 2013). This issue, which continues to arouse heated debate among the medical, social, and educational communities, is a prime example of the importance of methodologically sound sign language acquisition research and its practical application to the lives of deaf children and their families.

Although many methodological issues involved in sign language are similar to those involved in spoken language acquisition research, and though many approaches to sign language acquisition parallel those in spoken language acquisition, there are unique methodological challenges in studying sign language (Baker, van den Bogaerde, & Woll, 2005). As we describe below, such challenges are largely due to the low-incidence and heterogeneity of the population, the need for highly skilled and proficient signers to carry out the research, and the scarcity of existing assessment tools and instruments with which to reliability and reasonably investigate the sign language skills of deaf individuals.

Identifying and describing the population

It is estimated that approximately one in every 1000 infants is born with significant hearing loss (Kemper & Downs, 2000). Thus the population of deaf individuals is small and highly heterogeneous. As a result, identifying a group of individuals in whom to study sign language acquisition requires careful consideration. Here we describe some of the key issues that arise in this line of work, and examples of how researchers have addressed them.

Collecting background information

In studying language acquisition with cross-sectional or experimental designs participants are typically observed at a single point in time. Thus the question arises as to how to accurately assess their language background, including the age of onset of hearing loss, the degree of hearing loss, and the amount and type of language the participant has been exposed to throughout his or her life. All of these variables can contribute significantly to performance on the outcome measure(s) being studied. Deaf individuals are often exposed to spoken and/or signed languages in varying proportions at different ages, and the amount and type of input they receive varies widely. It is common for deaf children to be exposed to mixed input (e.g. a combination of signs and speech) from an early age. Thus it is insufficient to simply ask at what age the individual was exposed to sign language, as the *amount* and *quality* of language exposure can vary as widely as the age of exposure. Deaf children born to hearing parents may be exposed to sign language only a few hours a week, as part of an intervention program; they may be immersed in a signing environment as their parents and others around them learn to sign; or they may receive nearly all their sign input from school interpreters.

To address these questions, participants in any study should be given an extensive language background questionnaire. Researchers can develop a customized questionnaire suited to their research interests. In our laboratory, we ask participants to describe the type of language they were exposed to at every stage of their lives, asking about educational placement as well as language in the home environment. In order to assess whether sign language is their first language, we also ask questions about the degree to which they acquired and used spoken language, particularly if they were raised either partially or fully in an oral environment. We further ask participants to do a self-rating of their receptive and productive language skills, using

a 10-point Likert-type scale, which includes self-ratings on comprehension and production of sign language, fingerspelling, spoken language and written language. The goal of this extensive profile is to understand to what degree participants have been exposed to and acquired both spoken and signed language. This information can help us understand sign language usage that is puzzling or unpredicted; we also find that these self-ratings correlate with performance on psycholinguistic tasks (Chamberlain & Mayberry, 2008). If the participants are children, then we ask a parent, guardian, or other adult who knows the child's background well to fill out the questionnaire. The data from a background questionnaire provides a basis from which to compare participants on direct assessments of language ability.

Selecting and recruiting participants

In any research with a small and heterogeneous population, it can be a challenge to recruit sufficient numbers of participants per experimental group to conduct traditional statistical analyses. Thus in recruiting participants it is important to think about which variables are most important to control. When studying the effects of AoA on language proficiency, one must consider the age of language exposure, the amount of language experience, as well as chronological age (and level of hearing loss). One possible approach is to compare deaf adult participants who were exposed to sign language at birth, in early childhood, or in later childhood. Here, however, it is also important to consider total language experience (which is partially confounded with age of exposure). This can be addressed by limiting inclusion to participants who have been using the language for a certain minimum number of years, e.g. 10 years. It is also sometimes desirable to compare deaf participants to a control group of hearing participants. In this case, hearing and deaf participants can be matched on variables such as age, non-verbal IQ, or length of experience with sign language.

Regardless of the variables along which participants are matched, in working with the deaf population it is a challenge to obtain a sample of sufficient size for statistical analysis of data. Larger sample sizes are often attainable when it is possible for the researchers to travel to various sites; e.g. to residential schools for the deaf or large metropolitan areas where a sizeable deaf population exists, and collect data at those sites. In contrast, when the research must take place at a specific location, which is the case in most studies involving neuroimaging techniques or complex equipment, then participants must be obtained from a specific geographical area. In these cases, providing additional incentives for participation, such as travel reimbursement, may help. Finally, for studies collecting natural language samples, it is often necessary to travel to the child's home or bring the child and caregivers into a semi-naturalistic lab setting.

Gathering data: When and how to measure sign language acquisition

Longitudinal vs. cross-sectional research

As with any population, research on sign language acquisition can be approached either through cross-sectional approaches or longitudinal study, with accompanying advantages and disadvantages to each design. Longitudinal research in this population can be particularly informative, given the high amount of variability in deaf children's background experience. For example, important studies by Petitto and colleagues (Petitto & Marentette, 1991) established the existence of a manual form of babbling through a longitudinal study of American Sign Language (ASL) production in two deaf children at 10, 12 and 14 months. They found an increase over time in the proportion of each infant's gestures that met the criteria of manual babbling. Longitudinal studies of children of deaf parents have also been conducted to track the developmental time course of early vocabulary (Orlansky & Bonvillian, 1985). Having a child serve as his or her own control can reduce some of the impact of external factors such as family

characteristics, degree of hearing loss, and educational placement. If the data consist of observations of naturalistic behavior, it is ideal to obtain as much footage as possible, i.e. at least 30 minutes of time, from which a representative sample can be extracted.

Cross-sectional designs provide a faster snapshot than longitudinal ones, in that participants of varying ages are only assessed in a single session, although obtaining a sizeable group at a particular age range without introducing too much within-group variability is a potential concern. One large scale study of background and educational characteristics of deaf children with cochlear implants included over 180 participants, but involved four years of data collection (Geers & Brenner, 2003). In studies of signed vocabulary development in deaf children using adapted versions of the Mac-Arthur-Bates CDI parent checklist, researchers have collected data using longitudinal sampling (Woolfe, Herman, Roy, & Woll, 2010 for British Sign Language) and a combination (i.e. cross-sectional and partially longitudinal) design (Anderson & Reilly, 2002 for American Sign Language) to yield multiple data points over time documenting children's development.

As a third alternative, case studies have also been a highly informative source of sign language acquisition patterns in individuals from specific circumstances. Case studies can yield rich information from a very small number of participants (Brown, 1973). In particular, studies of children learning homesign systems without formal exposure to a full sign language have revealed the contributions of the child's mind to language development (Goldin-Meadow & Mylander, 1990). Additionally, longitudinal case studies of several deaf individuals who were not exposed to any first language until adolescence have shown how language is acquired in these circumstances (Morford, 2003; Ferjan Ramirez, Lieberman, & Mayberry, 2013). In these

very late learners, or linguistic isolates, it is highly informative to track language acquisition over time.

Comprehension vs. Production

The particular aspect of acquisition being studied necessarily guides the choice of a particular method or approach to assessment. At the broadest level, researchers must determine whether to study language comprehension, language production, or both. It has long been established that in most areas of language, comprehension precedes production (Nelson, 1973). Thus if a child produces a particular form, they are naturally assumed to comprehend it as well. The extent to which this also characterizes sign language development has not been investigated thus far. Studies of language comprehension use a variety of approaches. A common approach is picture-sign matching, in which a child is shown a sign and then asked to pick (i.e. point or click on) the matching picture from an array of two or more pictures. This can be extended to dynamic stimuli, such that the child sees a video clip of a sign or phrase and then is asked to pick the matching scene. Participants can also be asked to carry out an action depicted by a single sign or phrase (Newport, 1988). Such tasks have the advantage of being easy to score (e.g. a simple yes/no score for whether or not the child points to the correct picture). More complex studies of comprehension may include asking the child to respond to series of questions in order to assess comprehension of a signed sentence or story. In any comprehension study, task design is an important issue. As is discussed further below, one cannot simply administer a task developed for spoken language when collecting sign language data without considering modality-specific features of sign, e.g. the degree of iconicity, the ability to produce multiple structures simultaneously, or the extent to which the spoken language test material is representative of the lexicon and morpho-syntactic structure of sign language.

Studies of language production, in contrast, rely on techniques such as picture naming, language sampling, and elicited responses, e.g. sentences or short stories. Coding language production is significantly more time consuming and potentially more subjective than measuring comprehension, as the coder must determine the accuracy of the response. This issue highlights the importance of having highly proficient coders and/or consultants involved in research to evaluate the signs and structures being studied.

In analyzing children's language production, one important source of information is the overall developmental pattern observed for a particular linguistic structure. For example, foundational studies by Newport (1981) and Supalla (1982) on the acquisition of verbs of motion in ASL involved showing children short video clips depicting an animated character engaged in some action, and asking children to describe in sign what had happened. Through analyses of children's sign expression at various ages, a developmental pattern was observed in which children first acquire individual morphological components and only later combine them to produce complex forms.

A second important source of evidence gleaned from studies of language production comes from the analysis of error patterns, which can provide a window into children's understanding of generalizable principals of language and emerging knowledge of syntax. For example, longitudinal studies of handshape errors in young children's early sign productions have led to models of phonological development in the manual mode (Boyes-Braem, 1990; Siedlecki & Bonvillian, 1997; Conlin, Mirus, Mauk & Meier, 2000; Marentette & Mayberry, 2000). At the level of syntax, analyses of children's error patterns in production has revealed that children produce unanalyzed forms at a young age, and then gradually use some morphemes while omitting others, or use morphemes sequentially before combining them into more complex

forms (Newport, 1988). Studies of error patterns in children acquiring British Sign Language (BSL) through a picture description task were used to describe the protracted acquisition of complex verb constructions (Morgan, Herman & Woll, 2002).

Language production samples are also used to assess children's development of language beyond the word or sentence level. For example, studies of narrative development typically involve showing children a story—either through pictures, video, cartoons, or live action—and asking them to retell the story through sign language (Rathmann, Mann, & Morgan, 2007). To reduce memory demands, children are often given a picture book or set of pictures to refer to while retelling a story (Morford, 2003). Using this approach, researchers can observe children's developing use of narrative devices including connected discourse, sequencing of events, and anaphora.

Approaches to measuring language acquisition in deaf individuals

Assessment instruments

Pervasive among child language researchers is the search for the "perfect" assessment tool—one which is easy to administer, adequately captures and describes language ability at a point in time, has established validity, has been normed on a large group of children, and is fast and easy to score. Performance on such an idealized test can then serve as a means by which the language development of study participants can be sorted and/or controlled. In spoken language research, particularly with regard to English, there is an abundance of published assessments from which to choose, along with normed data from thousands of individuals. Unfortunately, for signed languages no such tools exist, and instead researchers have turned to an array of existing tools and/or have developed their own for their unique research purposes. Several sign language assessment instruments have been developed in recent years and new instruments are currently in

development (Haug, 2005; Haug & Mann, 2008; an extensive inventory of available sign language assessment tools is maintained at www.signlang-assessment.info). Because this line of research is relatively new, sign language researchers need to validate and supplement the results of such assessments with their own analyses of sign language development.

Many sign language assessment instruments are adaptations of tools designed for spoken language. One of the most widely used examples of this is the MacArthur-Bates Communicative Development Inventory (CDI) (Anderson & Reilly, 2002; Woolfe et al., 2010). The CDI is a powerful tool used in thousands of studies of spoken language acquisition, has been adapted for over 50 languages, and continues to be normed in additional languages (Fenson, Dale, Reznick et al., 1993; current information available online at http://www.sci.sdsu.edu/cdi/). The CDI is a parent report measure in which the parent checks from a large list of vocabulary items those words that the child either understands, or understands and says. The ASL adaptation of the CDI was normed on 69 deaf children between the ages of 8 and 36 months, while the BSL adaptation was normed on 29 deaf children in the same age range. The CDI targets vocabulary knowledge specifically. One major challenge in using the CDI with deaf children is the issue of who should complete the parent report. In many cases, hearing parents of deaf children are new learners of sign language themselves. These parents may not be familiar with all of the items on the list, and may not be fully able to assess their child's vocabulary. In some cases, the child's teacher or other early intervention specialist may be asked to fill out the checklist, provided that individual spends enough time with the child to have a detailed knowledge of his or her vocabulary skills. An advantage in using the CDI with deaf individuals is that, although it is normed for children up to the age of 36 months, it can often be a useful assessment tool for older children and even adolescents who are newly acquiring sign language (Ferjan Ramirez at el., 2013).

Other spoken language assessments have been adapted for use in specific research studies. For example, Schick and colleagues (Schick, de Villiers, de Villiers, & Hoffmeister, 2007) created an ASL version of the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 1997), a widely used measure of English vocabulary comprehension in which the tester produces a single word and the child points to the correct picture from four possible choices. In adapting the test for ASL it was necessary to take into account unique features of sign language, such as iconicity and phonological relationships among signs that are not present in the spoken English version of the task. Another adapted assessment is the ASL Sentence Reproduction Test (ASL-SRT; Hauser, Paludnevicience, Supalla, & Bavelier, 2008) for use with older children and adults, which is adapted from the Speaking Grammar Subtest of the Test of Adolescent and Adult Language (TOALT3; Hammill, Brown, Larsen, & Widerholt, 1994). In this production test, participants view pre-recorded sentences and are asked to reproduce them. Sentences vary in length and complexity. This test was designed to take approximately 30 minutes to administer and the same amount of time to score. It is currently being piloted for use with children and adults who are native and non-native signers. Finally, an adaptation of the semantic fluency test for BSL users (Marshall, Rowly, Mason, Herman, & Morgan, 2013) assesses participants' ability to name exemplars from specific semantic categories; this measure is very straightforward to score as one simply counts the number of named items.

Occasionally, deaf children's language is measured using spoken language assessments that have *not* specifically been adapted for sign language. For example, children's language skills may be assessed using the PPVT or the Preschool Language Assessment Instrument (Blank, Rose, & Berlin, 1978). In such instances, children's global language may be the target of assessment (e.g. English vocabulary), however the test itself may be administered in a variety

of modes, such as spoken language or signed English (e.g. Moeller, 2000). The advantage of such instruments is that large scale norms typically exist and the instruments are readily available for use. However, children's ability to perceive the instructions are often confounded with performance, and incorrect responses may be due to task demands rather than global language ability. Thus caution must be taken in interpreting results for sign language against norms for spoken language learners.

As an alternative to adaptations of spoken language assessments, efforts have been made to develop unique assessment instruments for sign language, either for use in a specific research study (Boudreault & Mayberry, 2006) or for widespread use among researchers and educators. An obvious advantage of such tools is that they are designed around the unique features of sign language, such as spatial grammar, classifiers, and fingerspelling. However, given the complexity of sign language, it is a challenge to develop an instrument that captures all of these aspects, with enough items to adequately sample knowledge of each structure, while still being relatively easy to administer and score. Examples of this class of assessment instruments include the BSL Receptive Skills Test (Herman & Roy, 2006), the ASL Assessment Instrument (**Hoffmeister, XX**) and the Assessment Instrument for Sign Language of the Netherlands (SLN) (Hermans, Knoors, & Verhoeven, 2010). In the BSL Receptive Skills Test, which has now been adapted for ASL (Enns, Zimmer, Boudreault, Rabu, & Broszeit, 2013), children see a short sign or phrase, and then are presented with four pictures and are asked to point to the matching picture. In this way the task is similar to the widely used Test for Reception of Grammar (TROG) (Bishop, 2003). The BSL-RST has been normed for 135 children, and is currently in the process of being re-normed on a large number of deaf children. The ASL Assessment Instrument includes several measures of receptive and productive skills and was designed for use

in educational settings in order to determine the relationship between ASL skills and English literacy in deaf students. Similarly, the Assessment Instrument for SLN is also comprised of several computerized tasks and is designed to measure a range of receptive and productive language skills. The latter two instruments are more comprehensive than some in that they aim to provide a more complete picture of an individual's language ability. It is likely that additional assessment instruments will continue to be developed to meet the needs of researchers looking to target specific proficiencies and educators seeking a metric by which to evaluate their students. Importantly, as new assessments are developed, there is a corresponding need for recruitment of fluent-signing researchers, and specified training for researchers and others in order to ensure that tests are administered and scored appropriately.

Language samples and naturalistic data

At the other end of the spectrum from structured language assessments are naturalistic language samples. To obtain this type of data, researchers either bring participants to a lab or travel to the participant's home, school or other setting and record them on video while engaging in communicative interaction with one or more partners. Foundational studies on children's early acquisition of facial grammar and affective facial expressions (Reilly, McIntire, & Bellugi, 1991) were obtained through systematic samples of children's spontaneous productions. It is possible to obtain spontaneous language samples without any structure, i.e. by videotaping the participants engaging in typical activities such as playing, eating, or reading with a parent. While this does typically yield a rich data sample, one disadvantage is the diversity of types and amount of language that may be obtained from different individuals, which makes group comparison more difficult. It is also possible that the particular sample yielded in a spontaneous sample will not be representative of the individual's typical language, due to such factors as self-

consciousness in the presence of the researcher or the specificity of the communicative topic. For this reason it is advisable to collect data on more than one occasion. Also, the researcher must decide whether to record the individual interacting with an experimenter, a peer, or with a larger group. In individuals with limited language ability it is often desirable to record group interactions, in which the participants carry out a typical conversation in a routine setting, such as eating dinner (Ferjan Ramirez et al., 2013). Once the language sample is obtained, an additional challenge is to know how much language constitutes a reasonable sample. Possible approaches include sampling a specific length of time (e.g. 30 minutes of interaction) or a specific number of sentences (e.g. one hundred utterances) (Brown, 1973). Using some constant amount of utterances or a fixed time sample enables comparison across individuals and points in time.

Another way to obtain a language sample is through a structured or semi-structured elicitation task. Examples include semi-structured interviews, story re-tellings, or personal narratives. Researchers have also used standardized pictures as a basis for language elicitation, or have asked individuals to describe a cartoon or movie sequence (Senghas & Coppola, 2001). For young children, one approach that we and others have used is to record a deaf child interacting with his or her parents, using the same set of toys and/or books provided by the researchers (Lieberman et al., 2014). This approach has the advantage of taking place in the child's home, which is a familiar and comfortable environment for the child, while keeping the objects constant and thus somewhat constraining the content of the accompanying language. Other researchers have recorded deaf children in a school setting (Lieberman, 2014; Singleton & Crume, 2010) to understand how children interact in a signing-rich environment, and often to compare children with deaf parents to those with hearing parents.

Data collection, analysis, and sharing

Regardless of the type of language sample obtained, an important methodological consideration is how to capture this data for later analysis. In particular, one must consider the placement and number of video cameras. In analyzing any type of interaction, it is crucial to have at least two cameras in order to obtain a direct view of each interlocutor. If the environment is a classroom or one that involves young children, it is sometimes necessary to have more than two cameras, to account for frequent movement and/or a large number of individuals participating in the interaction.

Once a language sample is obtained, there are countless additional issues to consider, including the type of transcription, coding, and linguistic analysis to pursue. Each of these decisions will be largely dependent on the specific research question, and particular approaches to transcription and coding are addressed elsewhere in this volume (see Chapters 5 and 6). Specific to acquisition research, however, is the decision about how to measure a child's language. Typical measures used in spoken language acquisition, such as mean length of utterance (MLU), can be a useful metric for assessment of syntactic development. However MLU is not a straightforward measure in sign due to the lack of widespread consensus regarding what constitutes a morpheme in sign language. In addition there are no large scale studies investigating how MLU increases over sign language development. Thus researchers must first invest time defining units of analysis in order to analyze a large body of language data in a systematic way. Possible alternatives to MLU include a count of total signs used in a given time period, type-token ratio, or number of signs per utterance.

Of particular interest to child acquisition work is the issue of data sharing. Due to the difficulty in obtaining a large sample of data, it is often advantageous for researchers to share

data with one another, so that multiple studies can be conducted on a single, comprehensive data set. In spoken language work, language corpora exist for many aspects of acquisition, and many of these corpora are transcribed, coded, and made available to interested researchers through a data exchange system, CHILDES (MacWhinney, 2000). With sign language data, an obvious challenge to creating a large corpus for data sharing is the lack of anonymity necessitated by the fact that participants' faces and bodies must be visible in order to see their language. With current widespread access to data on the web, it is difficult to maintain privacy. For children, this becomes a problem as children may be too young to give consent to have their image shared, and even if their parents consent to data sharing when their children are young, when those children become of majority age they may no longer wish to have their image widely available. This issue is relevant to research ethics, which is discussed in detail elsewhere in this volume (see Chapter 2). The unique concerns raised in acquisition data involve the use of children as participants and obtaining consent.

Other approaches: Computerized testing, neuroimaging, eye tracking

As the field of language acquisition has evolved, sign language acquisition research has advanced in parallel. In particular, new approaches to measuring language ability have been developed using technology that allows researchers to measure participants' responses to stimuli with a high degree of spatial and temporal resolution. Such techniques include the use of computers, brain imaging techniques, and automated eye-tracking technology that enable researchers to capture neural and behavioral responses that are not possible with simple human observation. Sign language researchers have kept apace with these new technologies through innovative and carefully designed adaptations. For example, tests that were originally developed using paper-and-pencil data collection have been adapted to be used on-line, enabling

wide distribution and automatic scoring. Automated eye-tracking techniques, which are used to study both language processing (Lieberman, Borovsky, Hatrak, & Mayberry, 2014; Thompson, Vinson, Fox, & Vigliocco, 2013) and reading (Bélanger, Slatterly, Mayberry, & Rayner, 2012) in deaf individuals show exactly where the participant's gaze is focused during a computer-based reading or receptive task. Neuroimaging techniques including EEG, fMRI and MEG reveal insights into neural correlates of language processing and, based on the particular technique, can give exceptionally detailed spatial and/or temporal information about when and how sign language is activated in the brain, and how early experience affects neural processing (MacSweeney, Water, Brammer, Woll, & Goswami, 2008; Mayberry et al., 2011) (see Chapter 18 for further information on neuroimaging techniques with sign). The combination of these newly developed and highly sensitive measures with established metrics of individual differences and language performance has allowed new links to be established between various indices of language and cognitive functioning.

Conclusions

The study of sign language acquisition can address fundamental questions about the nature of language, the impact of early experience on later performance, the impact of modality on learning, and the relationship between language and cognition. Regardless of whether the participants are deaf children with deaf parents, deaf children with hearing parents, or deaf adults, in studies of sign language acquisition careful consideration must be given to the characteristics of the population and the range of possible factors affecting performance. Sign language assessment is in a period of dynamic development and increased data sharing opportunities are emerging. As new technologies continue to be developed for the study of language acquisition and linguistic processing, sign language researchers have pioneered

exciting new methodologies which have enabled detailed analysis of language acquisition and processing.

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Key words:

Sign language, acquisition, assessment, methodology

Cross-References:

We refer to chapters in this volume on transcription and coding (Chapters 5 and 6), research ethics (Chapter 2), and brain imaging (Chapter 18).