Considering communication disorders and differences in the signed language modality[i]

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(Note: This chapter appears in the following:

Quinto-Pozos, D. (Ed.) (2014). *Multilingual Aspects of Signed Language Communication and Disorder*. Bristol, UK: Multilingual Matters.

See: http://www.multilingual-matters.com/display.asp?isb=9781783091294 for ordering information (print or ebooks available)

0.0 Introduction

Over five decades of inquiry into signed languages has allowed language and communication researchers to expand what is known about structural variation and human language, patterns of language learning, and the cognitive processing of language by children and adults. Surprisingly, comparatively little work during this same period has focused on signed language communication disorders even though there are likely thousands of signed language users (including school-aged children[ii]) throughout the world who possess some type of signed language deficit. Perhaps one reason for the lack of research on this topic lies in a major challenge faced by researchers. Specifically, there is much variation among deaf signers with respect to whether they have language input from models who are fluent in a signed language; this is true both for first exposure and for regular interaction with native or native-like language users. For many deaf children atypicality has been viewed as simply a developmental phase—something that is expected to "go away" as they get older. Unfortunately, this view has resulted, at least in some cases, in late identification of linguistic and/or cognitive deficits that could have been addressed earlier. This chapter and this volume are intended to serve as a resource for researchers and clinicians on the topic of signed language communication disorders, and on the question of how disorders of visual language might be considered within the contexts of deaf, hard of hearing, and hearing individuals who acquire and use a signed language.

1.0 Similarities & differences across modalities

A major question within this area of inquiry is the following: how are signed language communication disorders similar to or different from spoken language communication disorders? Presumably, we should expect multiple parallels across disorders of signed and spoken languages because of similarities between signed and spoken language structures and between the ways in which both types of languages are acquired by children. However, we might also expect characteristics of each modality to influence the types of communication disorders that appear in signers and speakers; some possible areas of consideration include the linguistic signal, the articulators used for language, and the articulator space. See Table 1 for a summary of the comparisons. In this section, sign and speech are compared in order to provide the researcher, the student, and the practitioner with a way to consider possibilities for communication disorders in signed languages.

1.1 Similarities

1.1.1 Signed languages are natural languages that are structurally similar to spoken languages

For decades, research has shown that signed languages are natural languages that can be described with reference to levels of structure that characterize spoken language such as phonology, morphology, syntax, and semantics/pragmatics (e.g., see Klima & Bellugi, 1979;

Emmorey, 2002; Johnston & Schembri, 2007; Brentari, 2012; Sandler & Lillo-Martin, 2006; Woll,). For example, lexical signs can be broken down into multiple phonological units with handshape, place of articulation, movement, and palm orientation values specifying how a sign is to be articulated.[iii] Linguistic descriptions of signed minimal pairs and performance-based slips of the hand (i.e., errors where target phonological features of a sign are incorrectly produced) provide evidence for the sublexical structure of sign (Klima & Bellugi, 1979; Hohenberger et al., 2002). Many authors have suggested that the movement of a sign is a key feature of signed syllables, although there is less agreement about the internal structure of the signed syllable (see Emmorey, 2007,Wilbur & Petersen, 1997, Wilbur & Allen, 1991). Consistent with the sublexical structure of signs, phonological disorders (e.g., Broomfield & Dodd, 2001) may appear in certain signers, with characteristic errors in one or more phonological values within signs (also see Corina 1998 for paraphasias in adult aphasics). One report of children's deficits with signed phonological structure appears in Quinto-Pozos, Forber-Pratt, and Singleton (2011), in which second-hand accounts of deaf children who struggle with movement, place of articulation, and palm orientation of signs are described.[iv] For that study, the authors interviewed professionals at bilingual (ASL-English) schools for the Deaf about their experiences with native signing deaf children who appear to be struggling with the acquisition of ASL.

Evidence of struggles with aspects of signed language phonology can be found in the language production of children who have been diagnosed with Autism Spectrum Disorder (ASD). In the current volume, Shield & Meier describe incorrect palm orientation or movement values that are produced by deaf children with ASD. For example, rather than fingerspelling with the palm facing toward an interlocutor, they sometimes have their hand turned toward themselves. This type of error is apparently unattested in typically developing children over the age of 18 months of age. The authors argue that the palm orientation errors during sign production are evidence of impaired perspective-taking abilities for the ASD children. A learner of a signed language must attend to orientation of the palm (i.e., the direction in which the palm in facing) order to correctly produce a sign since signs look rather different to the addressee than they do to the signer. Since perspective-taking is typically challenging for children with ASD (hearing or deaf), children who are acquiring a signed language may show effects within their linguistic development. The signing space and perspective taking are discussed in more detail in the next section. Shield and Meier also provide an extensive review of pertinent literature on ASD and provide other examples and suggestions of the types of language impairments that might be expected in deaf children who have been diagnosed with ASD. Their work represents some of the first writings on this topic (also see Denmark, 2011; Shield & Meier, 2012).

1.1.2 Neurological evidence for similarities across modalities

Research on brain structures that are crucial for language comprehension and production also suggests that we might expect some similar neurogenic disorders across modalities. There exists much evidence for adult disorders of signed language in the form of case studies of deaf stroke patients who were fluent in signed language before a cerebral insult (ASL: Emmorey, Corina, & Bellugi, 1995; Poizner, Klima, & Bellugi, 1987; Hickok, Say, Bellugi, & Klima, 1996; Loew, Kegl & Poizner, 1997; British Sign Language [BSL]: Marshall, Atkinson, Thacker, Woll, & Smulevitch, 2004). These aphasia studies indicate that brain structures commonly used by spoken language are similar to those used by signed language (also see Tyrone, this volume, for additional discussion). As would be expected, signers with damage to left hemisphere networks (in particular the inferior frontal cortex and the temporal lobes) have difficulty with comprehension and/or production of sign, whereas signers who experience damage to the right hemisphere do not have the same language problems.

Neuroimaging studies have also provided evidence for the important role of the right hemisphere in signed language communication. Although some researchers have found no differences between signers and speakers with respect to lateralization of language across modalities (e.g., MacSweeney et al. 2002), others have suggested that there is a greater involvement of the right hemisphere for sign over speech (Neville et al, 1998; Newman et al, 2002)[v]. With respect to production, signed language *classifiers* have been shown to recruit the use of right hemisphere. [vi] In particular, the placement and movement of classifier constructions have been shown to engage bilateral networks (Emmorey et al. 2005; Emmorey et al., 2012), and some studies even suggest that classifiers and lexical signs engage different hemispheres during production (Hickok et al. 2008). The use of right hemisphere networks for aspects of signed language production and comprehension supports the premise that the right hemisphere can play a key role in some aspects of language, although there are also many similarities across modalities with respect to the networks that are engaged.

The degradation of brain tissue and function that results in dementia (e.g., as an accompaniment to Parkinson's or Alzheimer's diseases) can also be the source of atypical or impaired signed language abilities. An early report describing patterns of signing in Parkinson's patients appears in Kegl & Poizner (1998); the authors also analyze the techniques that are used by interlocutors to compensate for the Parkinson's patient's lack of appropriate attention during signing and less-than-clear articulation (i.e., maximization of distinction in linguistic contrasts by the interlocutors). In a recent study Falchook et al. (2012) described the case of a deaf individual with Alzheimer's disease and her challenges with the production and comprehension of fingerspelling and grammatically complex sentences. The signer was also reported to exhibit impaired episodic memory, signs of anomia, an ideomotor apraxia, and characteristics of a visual-spatial dysfunction. Cases such as these have provided evidence that dementia affects signed language abilities in deaf signers, as would be expected.

Additional cases of dementia and its effect on signed language use are described in the chapter in the present volume from Spanjer, Fieret, & Baker. These authors describe various types of atypical language production that are evident in data from four older deaf users of Sign Language of the Netherlands (NGT) who are suffering from symptoms of dementia. In particular, they identify language problems that tend to also plague hearing users of spoken language with dementia, such as word finding difficulties, grammatical errors, and inappropriate (i.e., pragmatically odd) responses. Additionally, they carefully consider the bilingual status of those patients (NGT and Dutch) and why that aspect of language learning must be considered when addressing the linguistic abilities of deaf patients with dementia. The work of Spanjer and colleagues is particularly important because it considers the language and communication abilities of multiple signers and also considers the data from a bilingual perspective.

1.1.3 Similarities concerning childhood acquisition of language

Signed languages are acquired by native-signing deaf children following a timeline that largely parallels the acquisition of spoken language by hearing children (Bonvillian, Orlansky, & Novack, 1983; Newport & Meier, 1985; Petitto, 1987; Baker & Woll, 2008). Because of similarities in acquisition across the two modalities, we might also expect children to exhibit developmental signed language disorders paralleling at least some of those that have been identified and studied for spoken language. Symptoms of those disorders might be language delay, language processing deficits, and issues concerning language and memory (see Schwartz 2009 for an overview of child spoken-language disorders). Additionally, we might expect to find cases of Specific Language Impairment (SLI) in children acquiring a signed language (e.g., see Morgan et al, 2006; Mason et al, 2010; Quinto-Pozos et al., in submission), since SLI is a disorder of language comprehension and/or production that manifests in otherwise typically developing children (Leonard, 1998).

A chapter in this volume on deaf children acquiring British Sign Language (BSL) provides evidence for SLI in deaf signing children. The collective work of Herman and colleagues is notable because it represents the first set of in-depth studies that have considered communication disorders in signed languages. In their chapter for this volume, Herman, Rowley, Marshall, Mason, Atkinson, Woll, & Morgan describe the main components of their several-year study of atypically developing deaf children in the United Kingdom. They detail a survey methodology that they have used for the identification of atypically developing children and they describe the tests of BSL comprehension and production that they administered. An overall claim from multiple studies conducted by members of that team is that signed language disorders are to be expected in a fraction of the population matching the proportion of children expected to have SLI in the acquisition of English, or approximately 7% of deaf children (Mason et al., 2010, Herman et al, this volume). The sign disorders resemble delays in language acquisition rather than idiosyncratic examples of language production, not unlike hearing children's spoken language disorders. Without a doubt, the BSL researchers have been pioneers in this area of developmental research on communication disorder in sign.

Table 1: Similarities and differences between signed and spoken languages

Similarities	Differences
• both possess multiple levels of structure • both possess sub-lexical structure • both demonstrate hemispheric lateralization for language • both are affected by degradation of tissue in cases of dementia, aphasia, and brain insult • both demonstrate similar L1 acquisition milestones for native users	• signs articulated slower than spoken words • potentially more information in visual signal at any point in time • larger (paired) primary articulators and articulator space in sign • manipulable articulators in sign, not in speech • only partial visual feedback for signer compared with full auditory feedback for speaker • signing space used grammatically and topographically • partitioned lexicon in sign (core signs, fingerspelling-influenced signs, classifiers), less so in spoken languages • comparatively more iconicity in sign

1.2 Differences

One might also expect a subset of signed language disorders to differ from spoken language disorders because of key differences between sign and speech. The modalities differ with respect to the signal in which language is encoded (e.g., auditory versus visual) and and with respect to the articulators and articulatory space used for producing and comprehending language. There are also linguistic features of signed languages that might result in unique characteristics of at least some signed language disorders. In particular, it could be argued that signed languages appear different from spoken language with respect to characteristics of vocabulary items and how those items may be structured in the mental lexicon. The consideration of vocabulary items and related grammatical processes (e.g., a verb sign and its manner of inflecting for person and number) requires a discussion of iconicity and gestural resources and how those features of communication might influence signed language structures.

1.2.1 Differences in the linguistic/communicative signals

Since signed languages are typically perceived by the eyes rather than the ears (except in the case of tactually-produced and perceived signed language, which is used by many individuals who are deaf and blind; see Quinto-Pozos, 2002), it may be useful to highlight a few key differences between the auditory and visual signals. Light travels much faster than sound does, and the speed of light at small distances appears instantaneous to humans (see Brentari, 2002 for a discussion). Meier (2002) points out that for sign, the source of the signal (i.e., light) is external to the signer, whereas for speech the sound is generated within the speaker (also see Tyrone, 2007 for a discussion).[vii] Meier also suggests that the visual signal has the capacity to capture a greater amount of information than the auditory signal can relay in within the speech stream. This phenomenon can be exemplified by appealing to the concept of bandwidth as it applies to auditory versus video recordings; a 60 second audio file requires much less memory for storage than a 60 second video file does. It has been suggested that bandwidth differences could support an advantage in vision for vertical processing (i.e., processing simultaneously-occurring information), but not in horizontal processing (i.e., sequential information) across time (Brentari, 2002, Emmorey, 2007).

One question to consider is how characteristics of the signal might influence the ways in which language is processed. Presumably, the processing of sequential information is of particular importance for spoken language because sounds are strung together to form words, and multiple words are arranged in sequence to create a sentence. The importance of sequence has been captured within theories of perceptual processing and language impairment. For example, the Auditory Processing Deficit (APD) Hypothesis has been suggested to account for language deficits of hearing children (see Tallal & Benasich, 2002, for a review). The APD Hypothesis claims that the speed at which phonetic elements in the speech signal must be processed is too rapid for children who struggle with temporal processing; this causes a notable percentage of otherwise typically-developing children to exhibit developmental language impairment. Tallal's approach reflects the premise that children with language disorder can be characterized by a general slowing of processing vis-à-vis typically developing children (Tallal & Benasich 2002). Whether the temporal characteristics of the visual signal could result in processing difficulties that are specific to signed languages is unclear.

The processing of sequential information is requisite in sign, as in the processing of phonological sequences in signs (e.g., handshape or place of articulation changes) or syntax. However, the processing of simultaneous information is presumably of utmost importance for signed language because of the typical linguistic structures of visual-gestural language. In sign, the synchronous use of manual and non-manual articulators allows for the creation of multiple simultaneously-produced morphemes with information appearing on the hands and face;

sometimes movement of the torso and body are also significant. For example, a lexical verb in ASL such as DRIVE is produced with the hands, modification of the verb with quickly repeating path movements adds a simultaneously-articulated aspectual morpheme, and an additional adverbial modifier is communicated by postures of the lips and mouth area that encode information about the manner (e.g., carefully, haphazardly, etc.) in which the driving was conducted. Thus, linguistic and emotive facial expressions—in addition to manual articulations— are part of the signal to be deciphered by a viewer of sign. There is clearly much occurring simultaneously in sign. Spoken languages also allow for multiple simultaneously-produced morphemes (e.g., a lexical item produced with grammatical tone), although spoken languages generally prefer concatenative morphology, with strings of affixes being the typical realization of morphological processes.

The perception and processing of multiple layers of signed information simultaneously has been described in terms of parallel or vertical processing (Brentari, 2002; Emmorey, 2007), and this difference in comparison to spoken language is notable. Interestingly, the results of psycholinguistic experiments that employ gating tasks to examine sign recognition have shown that signs are identified more quickly than spoken words are (Grosjean, 1981; Emmorey & Corina, 1990), and handshape, place of articulation, and palm orientation are identified at the same time, whereas movement information is available later (see Emmorey, 2007 for a discussion of this two-stage process of sign identification). In addition, research on tip-of-tongue states (i.e., when a speaker or signer is having difficulty retrieving a word form even though they feel confident that they know the word) shows that the amount of phonological information that is retrieved simultaneously by signers is significant: signers are often able to remember up to three of the phonological features (e.g., handshape, place of articulation, palm orientation) of a sign, even though the sign itself could not be remembered (Thompson, Emmorey, & Gollan, 2005). These studies add support for the hypothesis that vertical processing is a psychologically valid concept. Whether or not the processing of multiple simultaneously-produced meaning units has an effect on children who are at risk for a developmental language disorder is an important question for researchers interested in signed language communication disorder. A main question to consider is whether some deaf signers might have difficulties managing the simultaneous processing that is required for comprehending and remembering important aspects of the visual signal.

One aspect of signed languages is notable for its sequential structure, and it provides evidence that horizontal processing is also important in signed language. *Fingerspelling* can be described as the manual production of letters of a written language alphabet. In ASL, the fingerspelling of English words constitutes approximately 5% to 20% of the lexical items in various types of language use (Morford & MacFarlane, 2003; Padden & Gunsauls, 2003); this includes the use of fingerspelling for proper nouns, for words that do not have single signs as equivalents, and for discourse-related purposes. There are also instances when fingerspelling is used in spite of the existence of a semantically-similar sign, although some commonly fingerspelled items undergo linguistic processes that allow them to resemble signs phonologically (Battison, 1978; Brentari & Padden, 2001). Fingerspelling is articulated quickly in comparison to lexical signs. Fingerspelling rate generally ranges between 3 to 8 letters per second, or approximately 125ms to 250ms per letter (see Quinto-Pozos, 2010, In submission; Zakia & Haber, 1971). This speed is comparable to ranges of syllable rate in spoken languages (see Dolata et al., 2008, Verhoeven et al, 2004), although not to common speaking rates of individual phonemes of words. Because of these rate characteristics of fingerspelling, it appears to be notably different than lexical signs, and it may be processed in unique ways. Importantly, the processing of fingerspelling also requires bilingual skills since fingerspelling represents the spelling of words from the ambient spoken/written language. Bilingualism is discussed later in this chapter.

Work on visual and auditory memory suggests that differences in the signal across modalities influence short-term memory performance. With respect to sequential memory tasks, it has been shown that fewer sequentially-viewed elements in the visual signal (digits or letters) are typically remembered when compared to sequences of elements that are perceived and processed via audition: on average, approximately 5 sequential elements for sign versus 7 for speech (Boutla, Supalla, Newport, & Bavelier, 2004; Emmorey & Wilson, 2004; Wilson, Bettger, Nicolae, & Klima, 1997). This generalization holds true whether digits or phonologically-balanced letters are considered (Bavelier, Newport, Hall, Supalla, & Boutla 2006). Importantly, the cause of the difference is not the ability to hear, but rather lies in constraints of visual sequential memory. Hearing bilinguals who are native users of both English and ASL perform differentially based on the modality in which they are tested (Boutla et al., 2004). Emmorey (2007), in appealing to Baddeley (1986) and his model of working memory, suggests that memory capacity in sign may be limited by articulation rate. Presumably, this is because signs are, on average, longer in duration than words and therefore may occupy relatively more space in working memory.[viii] Short-term memory differences across the modalities could presumably contribute to language disorders in different ways in spoken versus signed languages. At the very least, these differences should be considered since memory deficits have been implicated in many studies as a main factor in childhood language disorders (see Schwartz, 2010 for a review).

Another notable difference between sign and speech regards the extent to which the communicative signal produced by the sender is available to that person through sensory feedback (also see Tyrone, this volume). In speech, auditory feedback allows for a speaker to attend to their output and revise their language production appropriately. In sign, the language user often visually perceives her hands only peripherally, with some signs being largely out of the limits of vision (e.g., the ASL sign HORSE articulated with thumb contact on the temple), although the manual articulators do become a focus of attention in some cases (e.g., in classifier signs and for purposeful focus on a sign's articulation).[ix] It has been suggested that signers do not use visual feedback as a comprehension-based monitor, but rather as a guide to help modulate how much of the signing space they are using for articulation (Emmorey, Gertsberg, Korpics, & Wright, 2009). In addition to visual or auditory feedback, both signers and speakers do typically possess kinesthetic feedback from the articulators, and it may be the case that such feedback—along with tactile feedback involving the manual articulators—takes on a more important role in signing when visual feedback is limited.

Signal feedback is an important topic for communication disorders. As one example of this importance, auditory feedback during speech production has been suggested as a contributing factor in fluency disorders (e.g., stuttering) of speech (Civier, Tasko, & Guenther, 2010; Marist & Hutton, 1957; Neilson & Neilson 1987; Nudelman *et al.*, 1989). The argument is that a speaker exhibits more disfluencies when she is receiving auditory feedback than when she is not. In light of this work, it would be very useful to explore signed language fluency, with a focus on stuttering in signed language. It could be argued that the difference in visual feedback for sign might mitigate the prevalence of stuttering disfluencies in the visual-gestural modality.[x]

In the present volume, Whitebread discusses so-called stuttering in signed language. In doing so, he reviews past studies on the topic and discusses the rates of prevalence of stuttering that have been reported for deaf and hard of hearing school-aged children. By comparing the reported rates of stuttering in the deaf populations to prevalence and incidence rates for hearing children who use spoken language, Whitebread is able to highlight the importance of considering signed stuttering for theories of spoken language disfluencies that highlight auditory feedback. The author also provides a summary of the characteristics of signed stuttering that have been reported in older studies versus those that are commonly used to categorize types of spoken language disfluencies. In concert with other writings in this volume, Whitebread also considers the role of bilingualism, or the (occasional) use of speech by deaf signers, and its possible effect on sign disfluencies. This chapter synthesizes information about fluency in sign with a focus on stuttering that has not been presented elsewhere.

1.2.2 Differences in the articulators and the spaces they traverse

It is clear that there are differences in the articulators between languages across modalities (see Meier, 2002 and Tyrone, this volume, for additional comparisons), and these differences could have an effect on some of the language and communication disorders that arise within each modality. Signed languages capitalize on the use of two comparably large manual articulators (i.e., the hands) that exhibit a series of visible movements and static postures in the articulatory space during the production of signs. As noted in the previous section, the manual articulators are complemented—sometimes obligatorily—by multiple non-manual articulators (e.g., the torso, head, eyegaze, and facial features) for meaning creation. The articulators are not only visible in sign, they are manipulable; another person can help the signer position the hands and fingers to approximate a target form, which is potentially very useful for assisting the signer when intervention is needed (see Quinto-Pozos et al., 2010 for discussions of so called "signed language therapy"). Spoken languages, on the other hand, utilize comparably smaller articulators (i.e., the tongue, lips, glottis—along with movement of the mandible) for the production of speech, some of which are not visible (or only partially visible) to the perceiver of language. The articulators of speech are not manipulable by another person as they are in sign. In the case of speech, the mandible has been claimed to serve as the basis for oscillatory movements that, with the articulation of consonant and vowel segments, creates syllables in spoken languages (MacNeilage, 1998). In spite of the fact that several researchers argue for the existence of syllables in signed language (as noted earlier), there is little evidence for internal structure to those syllables (see Emmorey, 2007). The lack of a clear internal structure for a signed syllable may be a function of signed languages not having a primary dominant oscillator (like the mandible in speech) for the articulation of movement. The extent to which the parsing of the speech stream differs from parsing of the sign stream because of these fundamental differences in the signal has not been the focus of inquiry, although it might be useful for discussions of signed language communication disorders.

The use of hands for articulators could be a topic of inquiry for researchers who work on language fluency, the patterns of deficits that typically affect one's ability to articulate phonemes and phonological patterns effectively, and the intervention strategies that are employed by clinicians. As one example, it would be useful to examine limb apraxia to determine if childhood apraxia of speech (a difficulty in making the movements for speech) would have a parallel in the signed modality. Interestingly, signed language is sometimes used in interventions with hearing children who have apraxia of speech.

One of the chapters in the present volume focuses on sign production and neural pathologies that might have an effect on the articulation of signs. In particular, Tyrone reviews studies of sign production in American Sign Language and in British Sign Language with a focus on various motor disorders including limb apraxia, Parkinson's disease, cerebellar ataxia, and progressive supranuclear palsy. She proposes that examples of *sign dysarthria,* such as deficits in articulatory coordination, can be found in sign—just as in speech—because of the coordinated and complex movements that are involved in the production of signs. In addition, Tyrone suggests that different movement disorders appear to disrupt sign production in different ways, and those disorders can be dissociated from linguistic disorders that affect movement in a sign. Her conclusion based on the literature is that, broadly speaking, motor disorders have similar effects on the production of signed and spoken language. Her writings provide an important link between discussions of motor abilities and motor impairments across linguistic modalities.

With respect to articulator space, there are clear differences across communication modalities. The articulators of speech are bounded by a comparably smaller articulatory space (i.e., the oral cavity) than what is used by signed language articulators. The *signing space* has been described as "…a highly restricted space defined by the top of the head, the waist, and the reach of the arms from side to side (with elbows bent)" (Klima & Bellugi, 1979:51). A common argument is that it requires more time for the hands to traverse the articulatory space during the production of a sign than it does for the tongue to move around in the much smaller oral cavity. This difference could account for data that suggest that American Sign Language (ASL) requires, on average, approximately twice the length of time to articulate a sign than what is typically needed to utter a spoken English word (Bellugi & Fischer, 1972; Klima & Bellugi, 1979)[xi]. This may also be true of other signed languages, although it is not clear if some typologically-distinct spoken languages (e.g., polysynthetic languages with long words that contain multiple morphemes) would be more similar to a signed language in this aspect of timing. As one example, Hwang (2011) has shown that Korean, an agglutinative language, can be characterized as being closer to ASL in its rate of production of words, yet it is less similar when considering syllable or morpheme rates. In spite of the word-versus-sign difference, it has been reported that a measure of propositions per second (i.e., meaningful sentences) in ASL is similar to similar propositions in English. In could be the case that these motoric differences in the rate of movement of articulators might result in at least some different instantiations of communication disorder across modalities, although more research is needed in this area of inquiry.

Many researchers suggest that the signing space is multifunctional, and it is regularly used to indicate grammatical distinctions, location information for entities, and the depictive bodily actions of a signer. In some cases, the various uses overlap. It is clear that the signing space functions differently than the oral cavity does. This raises the question of whether aspects of these functions could lead to differences across modalities with respect to language and communication disorder. A brief review of some writings about the signing space follows.

Various authors have suggested that the *signing space* can be considered to function in multiple ways (e.g. see Emmorey, 2002; Perniss, 2012). *Shared space* is the use of the signing space in ways that takes advantage of the immediate environment (e.g., the signer will point to a dog located at its side to refer to that particular dog). *Abstract space* (also known as *grammatical* space) has been described as utilizing loci in the signing space to establish—via manual pointing, eyegaze, or direction of movement/placement of a sign—locations for referents that serve syntactic functions (e.g., pronouns, subjects or objects in a sentence, etc). *Topographic space* refers to the use of locations in the signing space to create a map-like depiction of a scene. The signer is using space topographically when she employs *classifiers* to indicate the location, orientation, and movement of objects with respect to each other. Finally, *viewer space* is the use of the signing space in a full-scale representation of characters interacting with other characters and the environment. Additionally, a signer can engage topographic space and viewer space simultaneously (e.g., by manually articulating a person classifier while also shifting one's posture and facial expression to portray aspects of a character), which is a complex skill that requires years of development for proper management (Emmorey & Reilly 1998; Morgan, 2002; Dudis, 2004). Even though spoken language does not engage the articulatory space (i.e., the oral cavity) in the same ways as signed language capitalizes on the space in front of a signer's body, co-speech gestures can be readily compared with a signer's use of topographic space and viewer space (Cormier, et al., 2012; Quinto-Pozos & Parrill, in submission).

From a neurological point of view, it is useful to consider how comprehension and production might provide insights about the linguistic processing of the signing space. Neurological evidence for a multi-faceted signing space first appeared in studies of deaf signing aphasics, which were mentioned earlier. Poizner, Klima, and Bellugi (1987) showed that adult signers who suffered strokes to the right hemisphere also possessed deficits in spatial skills that affected their communication. They argued for a dissociation between syntactic and topographical spatial skills (also see Emmorey, Corina, & Bellugi, 1995; Hickok, Say, Bellugi & Klima, 1996), and provided evidence for a dissociation of aspects of viewer space from grammatical space (Loew, Kegl & Poizner, 1997). Generally, the stroke patients in those studies performed similarly to normal controls on grammatical (i.e., syntactic) use of space; however they exhibited significant difficulties with topographical uses of the signing space. The patients also performed poorly on non-linguistic tests requiring spatial skills. Studies of normal signers (i.e., non aphasics) have also shown that the processing of space has some unique properties (e.g., see Capek, Grossi, Newman, McBurney, Corina, Roeder, & Neville 2009).

It could be the case that a deficit in visual-spatial skills could cause an otherwise typically-developing child to struggle with aspects of signed language that require certain functions of the signing space.[xii] For example, if a child fares poorly on tasks such as remembering the location and orientation of objects, then that child might struggle with classifier comprehension and production. The same child might be challenged when giving directions or explaining where something is located. Quinto-Pozos, Singleton, Hauser, Levine, Garberoglio, & Hou (2012, in revision) report such a case in their description of a native signing deaf adolescent who struggled with comprehension and production of topographic and viewer space, but not other aspects of ASL grammar. That child scored in the impaired range on various tests of visual-spatial skills, but she also performed within the average range on a general measure of ASL comprehension and production.

Various types of atypical development could also have an influence on how a child is able to engage visual-spatial skills during the process of language acquisition. As noted in the chapter by Shield and Meier (this volume), deaf children with autism often struggle to produce the correct phonological value for palm orientation for some signs, as the signer must perform a perspective-shift (180º) in order to be able to articulate those signs correctly. It has also been shown that signers who are not exposed to a full-fledged sign language in their youth do not develop visual-spatial cognition as robustly as those who are exposed to a sign language early (Pyers, Shusterman, Senghas, Spelke, & Emmorey, 2010). Interestingly, nonlinguistic visual tasks have also been shown to be difficult for hearing children with language impairment

(Windsor et al, 2008). It would be useful to consider possible similarities between visual-spatial skills and language acquisition across signed and spoken language.

A deaf adult signer who struggles with visual processing of the signing space would be particularly unexpected because it has also been shown that normal adult native signers of ASL possess *enhanced* visual-spatial skills—presumably due to their experience with a signed language (Emmorey et al., 1993; Emmorey & Kosslyn, 1996; Emmorey, Klima, & Hickok, 1998; Masataka, 1995; McKee, 1987; Talbot & Haude, 1993, Wilson et al. 1997), and there is some evidence that deaf children also possess enhanced visual-spatial skills (Bellugi, O'Grady, Lillo-Martin, O'Grady-Hynes, van Hoek, & Corina, 1990). Because of the enhanced visual-spatial skills, it may be difficult to identify impairment in this aspect of language and communication for adult deaf signers.

1.2.3 Differences in vocabulary inventories and grammatical structures

Signed languages, like spoken languages, possess words (i.e., signs) and grammars that govern the way the words are modulated and sequenced with respect to each other. However, it could also be argued that there are notable differences across modalities. Both types of languages contain content words (e.g., nouns and verbs) and function words (e.g., conjunctions, prepositions) although various function words (e.g., prepositions, articles, copula verbs, etc.) appear comparatively less frequently in signed languages. Signers also capitalize on the use classifier signs for various types of descriptions, which are highly productive and are used regularly within some genres of language use, such as narratives. Signed languages allow for modifications of signs in visually-iconic ways for the creation of specific meanings (Klima & Bellugi, 1979), and iconicity figures prominently in the sign modality (Perniss et al., 2010).

These characteristics of signed languages should be considered since they might influence the types of deficits that occur for children who struggle with word learning, word modification (e.g., inflectional morphology), and remembering a diverse set of words.

One model of the structure of the signed language lexicon divides lexical items into native and foreign items, the latter exhibiting influence from English via fingerspelling (Padden, 1998; Brentari & Padden, 2001).[xiii] Vocabulary items that have been influenced by English (via fingerspelling or the use of a handshape that represents a fingerspelled letter) can violate standards of phonological well-formedness characteristic of the native vocabulary.

Another characteristic of the signed language lexicon, according to Brentari and Padden, is that the native lexicon can be divided into core and non-core portions; the core includes signs that are highly stable and standardized in form and meaning, and used frequently in the language, whereas the latter includes classifier signs. Some authors have also suggested that the non-core is heavily influenced by gesture (Cormier, Quinto-Pozos, Sedcikova, & Schembri, 2012). The existence of a partitioned lexicon could have implications for how children acquire a signed language vocabulary and reach milestones of vocabulary development as they develop.[xiv] With respect to signed languages, it may be that children could show deficits in the development of one aspect of the vocabulary (e.g., the case of a visual-spatial deficit and its effect on the use of topographic space and classifiers), but not in others (e.g., the use of visually-iconic nouns).

One feature of signed languages that is particularly prominent is visual iconicity (see Taub, 2001). In Taub's terms, one type of iconiticy can be described as "the shapes of the articulators themselves and using them to encode images of similar shapes" (68) For example, the ASL sign TREE depicts a tree trunk and its branches via the arm and fingers of the hand, respectively. In spoken language, sound-based iconicity appears in onomatopoetic words, although signed languages possess more iconic devices than spoken languages (see Perniss, Thompson, & Vigliocco, 2010 for a review of iconicity in signed and spoken language).

The literature is mixed with regard to whether there exists a facilitative effect of iconicity with respect to vocabulary learning. Various reports suggest that young deaf children do not use iconicity as a tool for learning signs more quickly (Miller, 1987), for conjugating verb forms appropriately (Meier, 1987), or for learning the form-to-meaning mappings in their language more quickly (Morgan, Herman, Barriere, & Woll, 2008). Iconicity of target forms has been reported not to support more accurate children's productions (Meier, Mauk, Cheek, & Moreland, 2008). In addition, adults do not appear to use iconicity as a differential way of processing in a semantic priming task (Bosworth & Emmorey, 2010). However, other studies have shown that iconicity can have a facilitative effect. For example, iconicity could contribute to performance on tests administered in sign language (Markham & Justice, 2004), iconicity makes it easier for deaf children to learn new signs (Thompson, Vinson, Woll, & Vigliocco, 2012), iconicity can assist with processing for deaf children (Ormel, Hermans, Knoors, & Verhoeven, 2009), and adult L2 learners capitalize on iconicity to remember signs that have been learned (Lieberth & Belille Gamble, 1991). Without a doubt, iconicity is a prevalent feature of signed languages, and the degree to which it influences the way such languages are learned and processed—especially later in development when children can make the connections between iconic linguistic forms and the real-word objects and concepts that they symbolize—is worth considering, especially within the larger topic of communication disorder.

1.3 Summary of similarities and differences

This section has highlighted some of the similarities and differences between signed and spoken languages in order to allow for the consideration of communication disorders across the two modalities and where different disorders might be predicted to appear in sign. Multiple similarities exist between sign and speech, and evidence has been provided for some similar types of communication disorder in sign, in spite of the differences in the linguistic signal, the articulation of signed languages, and the ways in which visual-gestural languages are structured in terms of mental vocabularies. However, differences across modalities are important to consider because they force us to investigate whether signed language communication disorders could reveal unique aspects of processing and memory that are associated with visual-gestural space. More specifically, visual perception/processing and manual/non-manual articulation of signs within the signing space provide good test cases for spoken language theories of language and communication disorder.

2.0 Users of signed languages as default bilinguals

An important consideration for the investigation of signed communication disorders is that users of signed languages are commonly bilingual or multilingual (Grosjean, 2010), and this raises various questions with respect to the interaction between languages and the overall linguistic development of an individual. This is true whether someone is a hearing child of deaf adults (i.e., a *coda* or *koda;* kid of deaf adults), or a deaf/hard of hearing child. Deaf people are typically exposed to the ambient written language of their region, and in the case of deaf children this often occurs with their early educational experiences. In cases in which a deaf individual possesses s speech stream (e.g., hearing aid, cochlear implant, etc.), exposure to a spoken language constitutes a part of their linguistic experience. One other important point that has yet to be made is that there is also a visual signal connected with speech (i.e., speechreading), and deaf individuals are exposed to speaker's mouth, lip, and jaw movements during their production of speech. The extent to which these visual cues contribute to childhood language acquisition and/or adult learning is, unfortunately, an area that has received very little attention in the developmental literature (see McQuarrie & Parrila, 2009).

Many deaf adults and children are exposed to more than two languages. For example, a growing number of deaf children in the United States are exposed regularly to two different spoken languages (e.g., Spanish in the home and English at school), a signed language (e.g., American Sign Language [ASL]), and one or two written languages (English and possibly Spanish). Gallaudet Research Institute (GRI) data from 2010 report that 11.4% (or 4,409) of deaf and hearing-impaired children throughout the U.S. were raised, at least in part, in homes in which Spanish is the spoken/written language of the home, and that 9.4% (or 3,533) came from homes in which multiple languages were used. It is likely that some of the children in the latter category were also receiving Spanish input at home along with input from other languages. In all of these cases it is clear that deaf individuals are not like monolinguals who are exposed primarily to one language via speech and writing.

Multiple questions arise when considering the bilingual status of deaf individuals as it concerns disorders of language and communication, and there is a growing literature on disorders within bilingual speaking communities that can provide guides for how to consider bilingual communities and provide language services for these populations (e.g., see Kohnert, 2010; Sheng, Peña, Bedore, & Fiestas, 2012; Bedore & Peña, 2008). In general, such studies suggest that bilingual children are able to successfully acquire two (or more) languages as they develop, but their developmental patterns do not always resemble those of monolinguals, such as in areas of vocabulary development, cognitive control, & memory performance. In some areas, they outperform their monolingual peers (e.g., cognitive control), whereas in other aspects of development they appear to lag behind (e.g., aspects of vocabulary; see Bialystok 2009, for a review). What might deaf children who are acquiring more than one language (simultaneously for some, and sequentially for a small minority who might only receive input in a signed language at home from their Deaf family members) teach us about the acquisition of two (or more) languages in spite of possible communication challenges along the way?

2.1 Hearing children who simultaneously acquire a signed and a spoken language

Various researchers have described the bilingual acquisition of hearing children who are exposed to a signed and a spoken language from a very early age (e.g., Morgan, 2005; Petitto et al., 2001; Baker and van den Bogaerde, this volume; Chen Pichler, Lee, and Lillo-Martin, this volume; Kanto, Huttunen, & Laakso, 2013; Woll & Morgan, 2012). There are, however, fewer descriptions of linguistic deficits within this bilingual population of hearing signers.   In a recent report, Woll & Morgan (2012) provide an account of the English and BSL skills and selected aspects of the cognitive abilities of several hearing English-BSL users: twin females with Down syndrome (exposed to BSL by their Deaf parents), a child who was claimed to be mildly autistic and severely apraxic, and a child with Landau-Kleffner syndrome (LKS) who was exposed to BSL at age 13. In the case of the child with LKS, which is an auditory processing disorder involving phonology, English abilities were determined to be impaired, whereas signed language abilities were spared. Thus, as expected, the impairment of rapid processing did not affect the signed language development of the child. In the other cases reported by the authors, language abilities across modalities were comparable, which suggests that similar areas of linguistic structure and processing are affected for some of these bimodal bilinguals—depending on the etiology of the impairment. Each of these cases is different because of the children's unique profiles and the distinct syndromic conditions. In addition to this report, Morgan (2005) provides a brief description of a hearing child with Deaf parents who appears to exhibit language disorders in both English and BSL. Much can be learned about language acquisition from these bimodal bilinguals who demonstrate atypical development.

Other works have looked primarily at typical development among bimodal bilinguals. A report of children who reach their first linguistic milestones at the same ages as bilingual peers who are acquiring two spoken languages (i.e., *unimodal bilinguals*) can be found in Petitto et al. (2001). In that study, Petitto and colleagues show that the bilingual children are particularly sophisticated with respect to knowing which of their two languages they should use when addressing different interlocutors, and the authors also describe the language mixing patterns that characterize the bimodal bilinguals versus the unimodal bilinguals. One notable difference is that the bimodal bilinguals are able to mix languages simultaneously because they can sign and use spoken words at the same time, whereas the unimodal bilinguals exhibit sequential patterns of language mixing.

In the present volume, Baker and van den Bogaerde describe their approach for investigating the linguistic development of hearing children who are acquiring Sign Language of the Netherlands (NGT) and Dutch. As noted with respect to the Petitto et al. (2001) study, one unique aspect of this bimodal bilingualism (i.e., spoken-signed language bilingualism) is that the language user can engage in oral and manual articulations simultaneously. This type of language use allows for analyses that look closely at how the two languages interact throughout a child's development. Baker and van den Bogaerde focus on children's *code-blends*, or examples of utterances containing both signed and spoken language material. Along with their linguistic analyses of these children's productions, the authors also consider the influence of factors such as the form of input offered, family environment, and social attitudes. The authors suggest that although there are some differences from other unimodal bilingual children, these bimodal bilingual children can usually be considered to be typically-developing bilingual children. This work provides important data from NGT and Dutch about the role of bimodal bilingualism in childhood koda signers.

A second chapter in the present volume also takes up the case of hearing children from signing households, although these children, unlike the Dutch-NGT kodas in the Baker and van den Bogaerde chapter, are exposed to American Sign Language (ASL) and English. Chen Pichler, Lee, and Lillo-Martin examine some of the cross-linguistic influences between the languages, and they consider the roles of quantity and quality of input in their analyses. The authors also provide suggestions for maintenance and continued development of ASL based on practices that were followed at the Hearing and Speech Center (HSC) at Gallaudet University. One of the authors was a speech and language therapist at the HSC, and he was involved in the use of dynamic assessment techniques to evaluate the language skills of these bimodal bilingual children. The assessment techniques were designed to provide as comprehensive a picture as possible of a child's developing bilingual competency, with the goal of distinguishing language *disorder* from language *difference* influenced by ASL-English bilingualism. The authors note that bilingual bimodal children in the US vary widely in their English development, and they display characteristics that may be typical for a developing bimodal bilingual, but not particularly common in a unimodal bilingual child. Such differences constitute important areas to investigate through targeted linguistic research.

2.2 The acquisition of literacy as a facet of bilingualism

As noted earlier, the development of deaf signing children not only involves a signed language, but also a written form of an ambient spoken language. The investigation of the learning/acquisition of a written language by deaf children can provide valuable information about bilingual development, but it can also provide insight into language processing and, similarly, language and communication disorder. Various studies suggest that deaf children who struggle with reading tasks are at a disadvantage because of deficits in sound-based phonological awareness, a key component of literacy acquisition according to some researchers (e.g., see Musselman, 2000; Perfetti & Sandak, 2000). However, a meta-analysis of phonological awareness studies has shown that phonological coding and phonological awareness are only a mild to moderate predictor of reading ability for deaf children (Mayberry, del Giudicie, & Liberman 2010).

Other writings also suggest that a lack sound-based phonological awareness of the spoken/written language is not necessarily at the heart of the children's struggles (see Clark, Gilbert, & Anderson 2011; Miller & Clark 2011, Piñar, Dussias, & Morford 2011). Instead, other influences have been suggested as contributing to reading ability in deaf children such as the shallowness/depth of the orthography (Kargin, Guidenoglu, Miller, Hauser, Rathmann, Kubus, and Superegon, 2012) and deficits with structural (i.e., syntactic) knowledge (Miller, Kargin, Guldenoglu , Rathmann, Kubus, Hauser, & Spurgeon, 2012). Myers, Clark, Musyoka, Anderson, Gilbert, Agyen, & Hauser (2010) point out that minority status within the deaf community is also a factor that should also be considered with respect to the acquisition of reading.

There are likely a myriad of factors that contribute to deaf children's acquisition of literacy, although multiple authors have suggested that language ability (in a first language, such as a signed language) is an important one to consider. Accordingly, it has been shown that signed language skills correlate with reading ability (Emmorey & Petrich 2012; Freel, Clark, Anderson, Gilbert, Musyoka & Hauser 2011; Hermans, Knoors, Ormel, & Verhoeven 2008; Mayberry et al., 2010). This finding is supported by processing studies that provide evidence for activation of the signed language during reading comprehension (Morford, Wilkinson, Villwock, Piñar & Kroll 2011). It is likely that fingerspelling plays an important role in the acquisition of literacy since it can provide a child with a connection between aspects of manual language (e.g., handshapes and movements) and the sequences of letters that form the written word. It has been suggested that deaf children acquire fingerspelling in at least two stages: the first is as a holistic unit that represents the entire word or concept, and the second is the understanding of the individual letters that comprise the written word (Padden, 2006). The recent increase in studies of the role of signed languages in the development of literacy for deaf children is promising because it provides us with valuable data about the effects of bilingualism and how the case of deaf children can be considered in a more holistic fashion (i.e., focus is not only placed on development of literacy *or* signed language development, but instead both are considered).

2.3 Bilinguals summary

It is important to remember that those individuals who are exposed to signed language—whether they are deaf or hearing—are default bilinguals, and their language development should ideally be considered within that context. The extent to which spoken language will also play an important role in communication differs from individual to individual, although hearing children who are acquiring sign undergo development of their spoken language skills, too. Since (signed) language ability has been shown to be an important factor for successful acquisition of reading, presumably a signed language disorder could also play a role in the acquisition of literacy.

3.0 Deaf signers and multiple disabilities

In many cases, deaf individuals are also challenged by neurological, physical, and cognitive deficits that could have a noticeable impact on aspects of their signed language acquisition, including comprehension and production. These cases are important to consider since they provide additional challenges for the researcher, teacher, or clinician who is working with an individual suspected of having a linguistic or cognitive disorder. However, they may also provide an interesting viewpoint from which to consider the acquisition and continued maintenance of communication within the visual-gestural modality.

3.1 Deaf children and multiple disabilities

Various writings have indicated that a notable percentage of deaf and hard of hearing children have been diagnosed with a disability other than deafness, with estimates ranging as high as 40% (Guardino, 2008; Knoors & Vervload, 2003; Mitchell & Karchmer, 2006; Moores, 2001, van Dijke et al., 2010). Gallaudet Research Institute (GRI) data from 2010-2011 report nearly 34,000 Deaf and hard of hearing students in pre-K through 12th grade in the United States during that academic year, and of that number, approximately 5.3% were reported as having a developmental delay, 8.0% as exhibiting a learning disability, and 5.4% as being diagnosed with attention deficit disorder (ADD)/attention deficit hyperactivity disorder (ADHD). Several of the diagnosed disabilities could presumably have an impact on the acquisition and development of a signed language.

Some cognitive disabilities can be characterized by atypical *Executive Function* resources, (e.g. working memory, attention, etc), and these struggles would presumably present challenges for the robust acquisition of a signed language (Jones & Jones, 2003; Jones, Jones, & Ewing 2006). For example, a child with a diagnosis of ADD/ADHD may have difficulties focusing and/or maintaining their eyegaze in the direction of the signer, which could result, in theory, in the perception of incomplete messages and less-than-robust language input. Unlike spoken language, the signed language signal cannot be perceived if a viewer is not visually attending to the producer of language. Atypical attention could presumably also affect the development of joint attention, which has been shown to be an important strategy for the acquisition of language and general cognitive development (Lieberman, Hatrak, & Mayberry 2011, 2013; Visual Language and Visual Learning Science of Learning Center, 2012).

Autism is another cognitive disability that could influence a deaf child's acquisition of a signed language. In the present volume, Shield & Meier describe aspects of the language of deaf children who have been diagnosed with Autism Spectrum Disorder (ASD), and they summarize and contextualize previous studies on the topic—including those have focused on children acquiring British Sign Language (BSL). As noted earlier, deaf children with ASD might have challenges with visual perspective taking, which could affect aspects of their signed language phonology (i.e., specifically, correct interpretation of the signer's palm orientation for the production of fingerspelling and some signs). Whereas Shield has focused on phonological aspects of the manual articulators for his own work, other studies have looked at the comprehension of facial expressions by deaf children with ASD (Denmark, 2011) since children with autism are often shown to exhibit difficulties evaluating the mental states of others. Denmark conducted a study of deaf children acquiring BSL. She showed that a sample of 13 deaf childhood signers of BSL who had diagnoses within the autism spectrum range (age range 8.5 – 18 years) were not impaired with respect to general processing (i.e., comprehension) of facial expressions, although there were some difficulties with the production of affective facial actions in BSL and adverbial (i.e., linguistic) non-manual facial movements that accompany signs.

3.2 Motor impairments and deaf signers

Poizner, Bellugi, & Iragui (1984) suggest that movement deficits could be considered along linguistic, symbolic, and motoric levels, and it could be the case that one level reveals a deficit whereas the others do not. Motor impairments could cause difficulty with signed language production (e.g., see Tyrone this volume, 2007). As an example, a neuromuscular disease—such as a muscular dystrophy—would likely impair a signer's ability to move her hands/arms freely and quickly through the signing space; this may result in a production disorder. A neurodegenerative condition that affects motor control, such as Parkinson's disease, could also affect signed language production. For example, Brentari, Poizner, and Kegl (1985) describe handshape and movement anomalies that were demonstrated by two deaf users of ASL who had been diagnosed with Parkinson's disease. In comparison with normal controls, the Parkinsonian signers coordinated movements and handshape changes in ways that caused their signing to appear monotonous to observers, as reported by the authors. Brentari and colleagues also noted that the anomalies were likely the result of atypical motor planning. Tyrone & Woll (2008) also focus on the language-articulation effects of Parkinson's on a deaf signer's productions, but their case study concerns the use of British Sign Language (BSL). These authors discuss challenges with production that implicate handshape as the phonological parameter that seems the most affected in the Parkinson's patient. In particular, the patient often produced a lax handshape rather than one whose form matched the handshape targets for signs and fingerspelling. As noted earlier, Tyrone's work on motor impairments is also included in the present volume (see also Tyrone, 2007), in which she describes cases of sign dysarthria.

With respect to the linguistic and symbolic levels of processing suggested by Poizner and colleagues, studies of aphasic patients are particularly useful for understanding the ways that movement can be understood within the context of signed language. Specifically, the researchers considered the case of four deaf patients with aphasia and whether their manual abilities could also be characterized in terms of apraxia, a neural disorder of purposive movement. Of the four patients, one showed signs of ideomotor apraxia (i.e., difficulty gesturing to command or imitating gestures), whereas three did not. Their data provide evidence for independence of motor deficits of sign language from those of non-linguistic gesture. In other words, according to Poizner and colleagues, the movements of sign are driven by linguistic processes whereas that is not necessarily the case for movements of other communicative acts.

Possible connections between non-linguistic motor abilities and signed languages continue to be the focus of study for researchers. For example, Meronen and Ahonen (2008) claim that motor development is an important area of focus when considering deaf children and signed language acquisition. In their study, tests of manual dexterity (serial fingertapping) correlated with tests of ASL skills. This suggests that there is a connection between motor and language skills, which is a hypothesis that merits further work.

3.3 Deaf signers and syndromic conditions

Another consideration with respect to deafness and additional disabilities concerns syndromic conditions that are often accompanied by audiological deafness. In particular, what are the cognitive characteristics of the different syndromes and how might those features influence the acquisition and maintenance of a signed language? There are multiple syndromes that co-occur with permanent hearing loss, and the most frequent examples from one report are the following (listed in decreasing order of incidence): Down, Usher, Pierre Robin, Treacher Collins, and C.H.A.R.G.E (see Picard, 2004). In some cases, the syndromes are characterized by cognitive deficits (e.g., mental retardation in the case of Down and Pierre Robin) or other sensory deficits (e.g., blindness in Usher) and that could also have an affect on signed language acquisition. Much can be learned by considering deaf individuals who are audiologically deaf and who have additional conditions that may pose challenges for the acquisition and use of signed language. This is a population of deaf signers that could benefit greatly from research on disorders of signed language communication.

4.0 What types of signed language communication disorders might we expect?

Where might communication disorders in sign appear, based on what we know about the perception, processing, and production of signed language? As reported within this chapter, there are some preliminary suggestions based on previously published work (e.g., Herman et al., this volume, Quinto-Pozos et al., this volume), but this section lays out a few additional suggestions. At this early stage in the research on signed language communication disorders, some of the proposals provided here may appear primarily speculative, although the rationale for their inclusion is based on characteristics of the signal and the articulators and articulator space, and the suggested structure of signed language lexicons. The proposed challenges are outlined in Table 2, and the suggested benefits of the visual-gestural modality when considering language and communication disorders are outlined in Table 3.

Table 2: Possible challenges for compromised signed language users

Comprehension	Production
Possible difficulties in processing: • multiple simultaneously-realized morphemes • (rapid) fingerspelling • longer sentences or sequences of discrete items • shifts in perspective for comprehending use of topographic and grammatical space	Possible difficulties in production: • multiple simultaneously-realized morphemes (difficulty in planning for production) • multiple characters in discourse (difficulty representing differences between signer, signer as narrator, and signer as other character)
	Difficulty with motor control to produce: • complex movements and challenging postures (depending on particular motor deficit)

- multiple coordinated movements that are timed with respect to each other (e.g., path and hand-internal movement combined), including bimanual coordination
- fingerspelling at normal rates

4.1 Role of perception and processing

Signed language deficits might be expected in aspects of linguistic processing where visual processing of the signal is arguably more demanding—especially for the language user with specific deficits. For example, since the use of topographic space in signed language involves mental rotation and/or perspective-taking skills, a child or adult who is weak in those types of visual-spatial skills may struggle with full comprehension (and perhaps production) of those constructions. In such cases, the signers' resources for simultaneously processing linguistic information (e.g., handshape, place of articulation, syntactic function, etc.) and visual-spatial information (e.g., appropriate interpretation based on perspective) could be lacking. Such a phenomenon has been attested in several accounts of deaf signers (e.g., Atkinson et al., 2002; Penn et al., 2007; Quinto-Pozos et al., in revision; Shield & Meier, 2012, this volume).

A deficit could also presumably arise if an individual struggles with the processing of multiple types of information simultaneously. Since it is the case that various phonological features of a sign's onset are processed quickly and simultaneously (Emmorey, 2007), any disruption in the ability of an individual to attend to multiple bits of information at the same time could presumably cause a processing deficit that would surface in language comprehension.

Signers who possess particularly slow processing abilities could also be affected, especially with respect to the rapid processing of fingerspelling. As noted earlier, fingerspelling is produced with rapid changes in handshape in sequence, and this is true whether a signed language has a one- or two-handed fingerspelling system. The processing of such forms could be problematic for signers who struggle with processing speed, and there is also likely an effect of literacy that accompanies a struggle. If a child (or adult) has poor reading and writing skills, they may likely have poor comprehension of fingerspelling since they will not be able to translate the rapid sequences of fingerspelled letters into lexical items that can be interpreted within context.

In addition, because of sequential memory constraints for visual signals, we might predict that signed language users would struggle to remember all the components of a long string of signs, whereas users of spoken language would presumably perform comparatively better on the task of remembering a string of spoken words of comparable length. If, indeed, that were the case, a potential signed language deficit might appear for children with less-than-robust memory when presented with sentences (or sentences with lists of items) that are relatively long.

4.2 Role of production and processing

It might also be expected that language production would be affected for those individuals with processing deficits with respect to the simultaneous expression of multi-morphemic, simultaneously-articulated constructions. For example, some constructions in signed language narratives have been characterized as particularly complex, with the hands depicting entities in space (e.g., via classifiers), the torso and head movement depicting postures of a character within that space, and the face showing emotive and/or linguistic modifications, as appropriate (e.g., see Dudis, 2004; Morgan, 2002; Emmorey & Reilly 1998). Signers with processing difficulties (i.e., challenges of being able to produce multiple morphemes or perspectives simultaneously) would be predicted to struggle with such constructions because of their complexity (e.g see Penn et al., 2007; Morgan et al. 2008).

Processing deficits are not the only cause of challenges with deaf signers with respect to production. In some cases, motor movements might be limited or impaired, and this could cause a signer to struggle with correct productions. For example, the production of fingerspelling might be impaired if someone has a deficit in the ability to produce fine motor movements in relatively rapid sequence. Signs that require bimanual coordination could also be challenging for some impaired signers (e.g., see Tyrone, Atkinson, Marshall, & Woll, 2009). See Tyrone (this volume) for a discussion of various motor impairments and how signers with those impairments might be characterized with respect to phonological features of signing.

An important question to consider with respect to motor issues is whether a deficit can be linked to motor planning (i.e. processing) or motor control/coordination. A deficit in muscular control would presumably be a result of poor motor control or coordination rather than impaired motor planning. There is also the question of how motor abilities correlate with language abilities for signers. As noted earlier, studies have found relationships between the two skills for signers (e.g., Meronen & Ahonen, 2008).

4.3 Role of co-occurring cognitive deficits

One would also expect challenges for those signers who have been diagnosed with a neuro-cognitive condition that would affect an aspect of their cognition that is needed for problematic because it would not allow for optimal attention to the visual signal. This hypothesis seems plausible, although reports of such children are not common in the literature on deafness or ADHD/ADD. Of course, other cognitive deficits could also cause problems with signed language acquisition. For example, a child with a learning disability or a developmental delay could presumably show signs of deficits in their signed language abilities.

Another possibility is that a syndromic condition that affects auditory processing would have an effect on a bimodal bilingual's spoken language development, but not their signed language acquisition. This is exactly the type of case reported in Woll & Morgan (2012), with their case report of Stewart, a hearing individual with Landau-Kleffner syndrome (LKS).

Researchers from the UK have also reported the case of a deaf adult with Williams syndrome (WS) (Atkinson, et al., 2004; Woll & Morgan, 2012). This child fared poorly with respect to her performance on tests of visual-spatial skills, which would be expected of a patient with WS. There have been reports of deficits in spatial aspects of spoken language in hearing patients with WS (Laing & Jarrold, 2007; Landau & Zukowski 2003), although the BSL case describes visual-spatial challenges associated with the syndromic condition and the processing and use of the signing space in signed language. The deficits affected grammatical and topographical uses of the signing space.

4.4 Challenges with the acquisition of literacy skills

A bimodal bilingual child might exhibit difficulties with the acquisition of literacy if indications of a language disorder appear in one of their languages. For example, weak phonological awareness skills (either auditory-based-phonology or visual-based-phonology) could reflect weakness in some types of metalinguistic skills, and this may have an effect on the acquisition of literacy. A diagnosis of dyslexia for signing children is not uncommon (e.g., see Enns & Lafond, 2007, Miller et al., 2012), and the challenge for the investigator or clinician is to determine whether a weakness in reading skill is due to reading-specific challenges or a more fundamental problem in that individual's acquisition of language (either signed or spoken).

4.5 Predictions for signed language resistance to some communication disorders

It could also be the case that some types of language and communication disorder are not comparably represented in the signed modality. Presumably, a lack of representation may be influenced by the same characteristics that make the signed modality distinct from the spoken modality such as aspects of the signal and characteristics of the articulators and articulation space. See Table 3 for a summary of suggested benefits for signed language users.

Table 3: *Suggested benefits for compromised signed language users*

Comprehension	Production
Beneficial aspects of the signal: • iconicity may support comprehension and word learning • slower articulation of signs may result in comparably fewer temporal processing deficits • size and visibility of manual gestures may make signs easier to perceive and	Beneficial aspects of the signal & the articulators: • aspects of sensory feedback and bimanual articulation may result in lower prevalence of some disfluencies in sign (e.g., stuttering) • manipulable articulators may support language learning and communication intervention

recognize	• slower articulation of signs may result in comparably few motor coordination problems

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Earlier in this chapter it was suggested that reports of so-called signed language stuttering generally propose a much lower prevalence than what has been reported for users of spoken languages. In the current volume, Whitebread suggests that consideration of signed language stuttering could allow for the critical evaluation of theories that target auditory feedback as one of the primary factors that influences a person's degree of stuttering. Without comparable feedback, signers presumably do not have a similar type of interference from a feedback loop (see the section on visual feedback in sign), and this could mitigate potential fluency issues that would arise. However, there could be other possible reasons for less representation of stuttering among signers. One possibility is that the planning and coordination of bimanual articulation leads to comparably fewer problems with fluency in signed language. This is an area that could use empirical studies to tease investigate the possibilities.

As noted earlier, the rate at which signs are produce is generally slower than the rate at which spoken words are uttered—seemingly due to the size of the articulators in sign and the fact that they must traverse a larger articulatory space than that for speech. An important question is whether the slower temporal rate of the signed signal (at least for lexical signs, less so for fingerspelling) would lead to fewer deficits that are influenced by required speed of processing.

Even though there remains considerable debate about whether sign iconicity plays a facilitative role in the learning of new signs and general comprehension of a signed message, iconicity has shown by some studies to be facilitative, and iconic aspects of a signed vocabulary are worth considering. It may be the case that children and adults who are cognitively compromised would benefit from iconicity, although age could presumably be a variable to be considered.

Signs are highly perceptible to the typical viewer, which has been suggested as a possible reason for the degree to which they are recognized by caregivers in the early communication of their deaf children (Newport and Meier, 1985). This degree of perceptibility may provide a benefit to users who present with a deficit that impairs their ability to recognize and process signs.

Over the years there have been many examples of signed languages being used as resources for communication therapy for children and adults with language and communication disorders (see Bonvillian, Nelson, & Rhyne, 1981, Seal & Bonvillian, 1997). It would be worthwhile to consider why signed language allows for communication in cases when spoken language production is not successful. It could be that the speech articulators are more difficult to manage in comparison with the signed language articulators, although the comparison might be challenging to make based on different muscular structures and neural processes that manage the motor movements. However, there are aspects of the articulators and articulator space that may be useful when conducting communication intervention via signed language: the rate at which the articulators generally produce signs and the fact that they are manipulable. As noted earlier, signs are articulated slower than words are, but the articulation can be slowed down further to assist with language learning and intervention. An intentional slowing of the signal could also be possible in spoken language, but that may result in a distorted message. Because signed articulators are manipulable a signed language professional can assist a child or adult with the correct articulation of a sign.

5.0 Challenges of working on signed language disorders

There exist various challenges with the task of conducting research on communication disorders within the signed modality, and this has also been suggested by other authors (e.g., Morgan, 2005). One of the primary challenges concerns the availability of instruments for assessing the language and communication of deaf individuals—both children and adults. Unfortunately, it appears as though natural signed language has generally not been considered in past research on communication disorders and approaches to intervention for deaf children and adults. There are also some challenges that are related to characteristics of the population of daily signed language users. Each of these topics is treated within this section.

5.1 Availability of assessments

There is clearly a lack of (normed) instruments that focus on language and communication with which to assess signing (both deaf and hearing) individuals. Mann & Haug (this volume) highlight this point in their chapter while providing a context for understanding the types of language and communication assessments that have been available until the present time. The authors note that there are four broad categories of assessments that exist: 1) tests for sign language acquisition, 2) tests for educational purposes, 3) tests for research on linguistic and cognitive development, and 4) tests for adult second language learners. In some cases, a single test might be used for multiple purposes. Critically, Mann & Haug provide a cross-linguistic perspective to the topic of signed language assessment because they perform a broad-based review of instruments that have been created in various countries. This is particularly important for those signed languages that do not have as extensive a history of research. The authors also provide suggestions about how to create tests that are reliable and valid. This could serve as a very useful resource for researchers and clinicians throughout the world.

The vast majority of tests that have been developed for assessing signed language were not designed with the primary purpose of identifying children or adults with language or communication deficits. Such diagnostic instruments are lacking, although there have been recent efforts to change this, such as the creation of a BSL non-word repetition test, with the goal of serving as one measure deaf signing children's language impairment (Marshall, Denmark, & Morgan 2006; Mann & Marshall, 2010; Mason et al, 2010). Other tests and checklists might also be able to identify low performers reliably (e.g., Anderson & Reilly, 1998 for ASL and Baker & Jansma, 2008 for Dutch-NGT).

The tests that have been developed for research purposes may not necessarily be available to language/communication professionals to use with children in their schools. Instead, schools generally develop their own in-house assessments. The manner in which this is done differs from school to school, but developmental professionals (e.g., ASL specialists, school psychologists, speech and language therapists) may create ways to assess the children in their school, such as by using video to capture language samples and analyzing the product based on check-lists of linguistic/communicative features (Quinto-Pozos et al., 2011). The efforts and gains that have been made by these professionals are noteworthy, especially since they have not been able to turn to commercially-available normed instruments to serve as resources.

5.2 Availability of literature resources

Perhaps a related issue concerns the lack of writings on signed language communication disorders. There is typically not much discussion of signed language at professional gatherings of researchers and practitioners (e.g., speech and language therapists), where the focus is normally on audition and speech, and researchers who work on signed languages do not have access to a body of research on communication disorder in the visual-gesture modality. Generally speaking, there appears to be minimal discussion at scholarly meetings of communication disorders experts about the typical or atypical acquisition of a signed language by deaf children, with only some representation in the form of an occasional oral or poster presentation[xv]. In addition, some school professionals who work with deaf children (e.g., speech language therapists, school psychologists, physical & occupational therapists, etc.) may not be familiar with the general milestones that deaf children should reach at different stages of their signed language development.

It is the case, however, that signed language is used by researchers and clinicians for augmentative or alternative communication with hearing patients, such as with children who are diagnosed with autism spectrum disorder (see Bonvillian, Nelson, & Rhyne, 1981, Seal & Bonvillian, 1997). In some of those cases, the learning of signs by the autistic children has been reported to aid communication. However, it is likely that the children in these cases were not generally exposed to the full linguistic system of a signed language—including both lexical items and grammatical structures. Rather, the autistic children exposed to signed language may have mostly learned isolated signs, and it is questionable whether the same children use the signs regularly (i.e., outside of the experimental setting) for communication (Bonviallian & Blackburn, 1991).

In addition to the dearth of published research studies on signed communication disorders, there is also a lack of documented intervention strategies in the literature for assisting deaf and hard of hearing children to improve in areas of signed language development that are noticeably delayed or atypical. It is the case that some clinicians have developed their own strategies, which are based on their experiences with interventions with children acquiring English (e.g., see Quinto-Pozos et al., 2011), yet the grammatical differences between English and ASL and the difference in modality between the two languages (e.g., perception, production, etc.) does not allow for a straightforward comparison. Unfortunately, a similar situation exists in the cases of deaf adults who are in need of language therapy after a neurological insult such as a stroke or brain injury; the rehabilitation that speech and language therapists have been able to engage in with this population in the past has been limited (Marshall, Atkinson, Thacker, Woll, 2003).

5.3 Characteristics of the target population

Characteristics of the target population also present challenges for work on communication disorders in signed languages. If a researcher would like to avoid the confound of late exposure to language, one issue concerns the estimated size of the target population of deaf signers who are exposed to a natural signed language from birth. Most deaf children have parents or caregivers who are hearing (over 90%, according to estimates; Mitchell & Karchmer, 2004); presumably, the vast majority of these adults who interact with young deaf children regularly do not sign. According to GRI data from 2010-2011, only 5.8% of Deaf and hard of hearing children (slightly over 2,100 children) are exposed to American Sign Language (ASL) in the home. For a subset of the remainder of D/HH children, it may be the case that atypical aspects of signed language development are caused by delayed exposure to rich linguistic input rather than some other cognitive or neurological aspect of development. If one were conducting research on communication disorders in signed language with a focus on deaf children who are exposed to a sign language from birth, there would be a small number of children who would be potential participants in a research study. This is clearly a challenge for investigators. Among other things, this makes it difficult to design a group study in order to address individual variation within this population. This constraint also forces a researcher to work with multiple schools in order to locate various children who are appropriate for a study.

In this volume, Quinto-Pozos, Singleton, Hauser, and Levine describe a multiple case-study methodology that they have employed for studies of atypical development in native signing children who are acquiring ASL. They focus on children who experience robust exposure to ASL (in the home and at school) in order to rule out effects that may be caused by delayed or impoverished input. In the chapter, the authors outline the challenges of performing research on atypical signed language development, and they also describe the ways in which they work closely with schools for the deaf in order to recruit and study focal children (i.e., atypically developing deaf children). Quinto-Pozos and colleagues also describe their approach for assessing the focal children—by using a combination of linguistic and cognitive assessments. As they point out, their approach may not be suitable for all cases of suspected deficit, but it does allow for careful examination of individual children that can potentially inform theory and provide much needed information for creating intervention strategies for such children.

Comparatively less demographic information has been reported for hearing children who are born into households with (Deaf) signing parents or siblings. These children (like those discussed in this volume in the Baker & van den Bogaerde and Chen Pichler, Lee, & Lillo-

Martin chapters) are exposed to signed language from a young age, and they are developing as bilingual bimodal children. Unfortunately, the development of these children is not the focus of many studies, which restricts the degree to which we understand their development from a population standpoint.

It has been reported that timely identification of atypical signed language development may also be an issue that needs to be addressed (Quinto-Pozos et al., 2011). As suggested in the introduction, it is not uncommon for professionals to view atypicality as a developmental phase and something that is expected to "go away" as they get older. This lack of early identification may be due, in part, to the lack of marketed assessment instruments—whether they be diagnostic or not—that professionals at schools can use to chart a child's developmental progress. As noted, it can also be difficult to determine if a child with late exposure to signed language has language problems in addition to being delayed with the acquisition of the signed language.

6.0 Where do we go from here?

There is much to be learned about communication disorders by considering data form signed languages. As has been described in this chapter, there exist similarities and differences across language modalities with respect to perception, processing, and production. The similarities allow for logical comparisons across modalities, and the differences force researchers and clinicians to carefully consider aspects of signed languages that have previously not been included in our general knowledge base about human communication.

For the future, it would be useful to continue in the quest to determine which disorders are influenced by language modality versus those that could potentially be universal for language users across both modalities. Presumably, there would be various similarities because of the ways in which language is acquired—and lost—across signers and speakers. Many notable similarities about communication have been pointed out in spite of differences in the primary channels of communication. However, as outlined in this chapter, there are important differences across modalities that should be considered (e.g., characteristics of the signal and the articulators and articulator space for signed languages) that could provide insights about those aspects of language processing and production that are not necessarily universal. Not only could this research provide evidence for what is unique to hearing or vision with respect to language perception and processing, it would inform the research community about what is generalizable for all users of language. Additionally, since there are notable differences with respect to the motor abilities needed for the production of speech versus sign, a focus on those differences and the types of impairments that occur (or may be predicted to occur) in sign would be extremely useful.

In regards to applying what is learned to the practice of intervention, one approach is for researchers and schools to form more mutually-beneficial partnerships. Developmental professionals at schools could benefit from additional resources for assessing their students and providing key aspects to diagnostics. In addition, speech and language therapists could benefit from studies that explore intervention strategies that provide approaches for signed language therapy. This area of research is ripe for translational approaches. With respect to assessment instruments, regular communication between researchers who design tests and schools could support the creation of assessments that are valid reflections of the types of language knowledge and skill that is expected from typically-developing children at various ages. This would allow for benchmarks from which to compare children who may be underperforming in various areas. In addition, researchers could benefit from having partnerships with schools that assist with the recruitment of potential research participants (both typically- and atypically-developing children) so that the body of research data on this topic could continue to grow and benefit researchers, clinical practitioners, educators and language professionals at schools, and the deaf individuals who are struggling with linguistic and/or cognitive deficits.

As mentioned in the introduction, over five decades of inquiry into signed languages has given us the opportunity to advance our linguistic knowledge of structural variation, patterns of language learning, and the cognitive processing of language by children and adults. Unfortunately, comparatively little work during this same period has focused on signed language communication disorders, but the authors of the chapters in this present work would like us to believe that this will change in the near future. I optimistically agree with that sentiment.

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[i] I wish to thank Richard P. Meier, Jill Morford, and Martha Tyrone for comments on earlier versions of this chapter. Any errors and misinterpretations of the literature are my own.

[ii] With respect to the United States, Gallaudet Research Institute (GRI) data from 2010 report

[ii] With respect to the United States, Gallaudet Research Institute (GRI) data from 2010 report nearly 38,000 deaf and hard of hearing school-aged students throughout the country. If Specific Language Impairment (SLI) was represented among deaf children in rates similar to those reported for spoken language acquisition (approximately 7% of population, see Mason et al., 2010; Tomblin et al. 1997), there would be over 2,600 children in the US who might exhibit SLI with respect to their ASL acquisition.

[iii] In some cases, additional salient aspects of a sign's articulation may be important for the specification of a sign such as where, if at all, contact occurs between the articulators, and whether specific non-manual signals are used. Movement can also be divided into path movement and hand-internal movement.

[iv] It should also be noted that a study of typically-developing native signers of ASL reports that handshape is the phonological parameter with most errors for young children, whereas place of articulation exhibits the fewest errors; path movement lies between these two (Cheek, Cormier, Repp, and Meier, 2001). Interestingly, no handshape errors were reported for the atypically-developing children that were discussed in Quinto-Pozos et al. (2011).

[v] Also see MacSweeney et al. (2002) for a review of comprehension studies.

[vi] The term *classifier*, in the context of signed languages, is used to refer to various communicative devices that depict the motion, location, and/or geometric description of objects. It most commonly refers to handshapes that are used to depict an object in its entirety, such as an ASL 3-handshape to refer to a vehicle and a bent-V handshape to refer to an animal. Other devices called classifiers are used to describe objects (i.e., provide information about the size and/or shape of an object) or how objects are handled. See Supalla (1982) for an early description of ASL classifiers, including developmental milestones for their acquisition and Schembri (2003) for a general discussion of signed language classifiers.

[vii] Of course, it is also true that light must be present in order to perceive physical changes in the environment, which makes viewing signed language in dark spaces difficult or impossible without tactile information.

[viii] The next section provides details about the articulators of signed language and articulation rate.

[ix] Of course, signers also use kinesthetic and tactual feedback when producing signs. In fact, these types of sensory information comprise the full signal for deaf-blind signers who use tactile sign language, which provides evidence for the robust nature of those signals for communication.

[x] It may also be the case that differences in planning and coordination demands between sign and speech may lead to differences in the prevalence of stuttering across modalities.

[xi] The slower articulation time in sign versus speech has also been used as an argument to account for sign errors data (i.e., slips of the hand) and the comparably faster repair of sign errors (i.e., toward the beginning of a sign's articulation) over speech errors (Hohenberger et al., 2002).

[xii] See Penn, Commerford, & Ogilvy (2007) for data from deaf adults that support this premise.

[xiii] Foreign items could also appear in spoken languages and follow different constraints than core or native items (e.g. Brentari & Padden, 2001 cite Ito & Mester 1995 for Japanese, also see Hancock 1995 for a description of Vlax Romani), although spoken languages do not capitalize on iconicity of forms to the extent that signed languages do.

[xiv] Other proposals suggest that signs are organized in a mental lexical according to lexical families that can be described in phonological and semantic terms (Fernald & Napoli, 2000) or with primacy to phonological onsets but not to any single phonological aspects of a sign such as handshape or place of articulation (see Emmorey, 2007 for a review).
[xv] Two notable counter examples are the thematic panel sessions held at the Symposium on Research in Child Language Disorders (SRCLD) in 2002 and the Society for Research on Child Development (SRCD) in 2009 and 2013.