A look at the other 90% - Investigating British Sign Language vocabulary knowledge in deaf children from different language learning backgrounds.

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Abstract

In this paper we present new data on deaf children's receptive and expressive vocabulary knowledge in British Sign Language (BSL) from a sample consisting of children with deaf parents, children with hearing parents, and children with additional needs. Their performance on three BSL vocabulary tasks was compared to (previously reported findings from) a sample of deaf fluent signers. We use these data to assess the effects of some key demographic/child variables on deaf signing children's vocabulary and discuss findings in the relation to the meaning of 'normative' data and samples for this heterogeneous population. Findings show no effect of the presence of additional disabilities on participants' scores for any of the three tasks. As expected, chronological age is the most significant factor in performance on all vocabulary tasks while the number of deaf relatives only becomes statistically significant for the form recall task.

The paper contributes to the field of sign language assessment by seeking to identify key variables in heterogeneity and how these variables affect signed vocabulary acquisition with the long-term objective of informing intervention.

Introduction

The significance of early vocabulary in spoken language has been well documented in the literature. Vocabulary is essential for communicating, reading, thinking and learning, and predicts young learners' literacy skills, social skills, and/or later academic achievement (Benner, Beaudoin, Kinder, & Mooney, 2005; Lee, 2011; Lervåg & Aukrust, 2010; Romano, Babchishin, Pagani, & Kohen, 2010; *inter alia*). This applies equally to deaf language users, regardless of language modality, i.e., sign and/or speech (Luckner & Cooke, 2010). However, vocabulary knowledge is less complete or diverse for many children with severe to profound hearing loss, who tend to be several years behind their hearing peers in their oral vocabulary development (Davies et al., 1986) and whose difficulties include not comprehending multiple meanings of words (Paul, 1998).

These delays in vocabulary development are likely due to the extremely varying language environments that deaf children experience, ranging from signing deaf parents to hearing parents who communicate only through speech. Only a very small proportion (5-10%, Mitchell & Karchmer, 2004) of deaf children have deaf parents. Those deaf children who grow up with deaf parents generally receive exposure to language (i.e., sign) from a very young age and are able to reach early developmental milestones at rates that are comparable as typically developing hearing children (Anderson & Reilly, 2002; Lillo-Martin, 1999; Newport & Meier, 1985; Woolfe, Herman, Roy & Woll, 2010).

In comparison, deaf children born to hearing parents vary greatly with regard to the regularity of their exposure to consistent and meaningful language input. As a result of this variability, many of the children in this group show delays in language development in general and vocabulary development specifically (Lederberg & Spencer, 2008). Some of the effects show up in the form of smaller spoken lexicons that develop at a slower pace and tend to be more variable compared to the lexicons of hearing children (Blamey, 2003; Lederberg & Spencer, 2008, Prezbindowski & Lederberg, 2003). Even in cases where deaf children receive sign language input from their hearing parents, their productive vocabulary may be reduced to utterances of only one or two signs as a result of the (hearing) parents' lack of fluency in sign (Lederberg, 2003; Meadow-Orlans, Spencer, & Koester, 2004).

Influencing Factors on Deaf Children's Lexical Acquisition

Consistent with the sociolinguistic complexities and heterogeneity of the deaf population, the list of possible key factors that affect their successful lexical acquisition is long. Factors may include onset of deafness, age of diagnosis, type of amplification, parental hearing status, age of language exposure, and the identification of any additional disorders (Anderson, 2006). The significance of many of these factors has been well documented in the literature, specifically age of onset of deafness (Allen & Osborn, 1984; Marschark & Spencer, 2003), age and level of sign language exposure (Mayberry, 1993, 1994; Mayberry & Eichen, 1991; Mayberry & Fischer, 1989), parental hearing status (Erting, 1994; Mitchell & Karchmer, 2005; Morford & Mayberry, 2000; Moores, 2001; Padden & Humphries, 1988), and quality of language input (Singleton & Newport, 2004).

Deaf children's language experiences vary considerably, ranging from deaf parents, who provide early access to language through sign to hearing parents who communicate exclusively through speech. This range is reflected in children's (sign) language skills. In order to determine a child's language proficiency level, researchers collect demographic information such as age of first exposure to language, which is known to affect speed of language acquisition (e.g., Boudreault & Mayberry, 2006). At the same time, this type of data can provide important insights into the extent to which non-native signers deviate from the prototypical native profile (Costello, Fernandez, & Landa, 2008) and give a more well-rounded picture of the many language external factors that have an impact.

Deaf Children with Additional Disorders

Carrying out reliable research in the field of Deaf Education is particularly challenging given the small size and the heterogeneous nature of the deaf population. This is further compounded by the existence of additional needs in approximately 30-40% of deaf children (Lesinski et al., 1995; Fortnum et al., 2002; Filipo et al., 2004) although this number is confounded by differing definitions of what constitutes these needs (McCracken & Turner, 2012). Among the most frequently observed needs are learning disabilities, visual impairment, specific learning disability, dyslexia, cerebral palsy and emotional/behavioral problems (McCracken, 1998). The lack of available language assessments that are appropriate for use with deaf children limits clinicians and teachers in their abilities to accurately determine children's level of vocabulary proficiency, diagnose additional disabilities, and to design appropriate intervention measures. Those vocabulary tests commonly used by clinicians, such as the Peabody Picture Vocabulary

Test (PPVT), the Expressive/Receptive One –Word –Picture Vocabulary Test have been developed and normed for/on hearing children. There are no comparable vocabulary tests for deaf children.

It has been established from research on hearing children that specific language impairment and dyslexia, as well as disorders that primarily affect non-linguistic cognition, including Down Syndrome, Autism, Williams Syndrome, can impact on vocabulary acquisition and phonological production (Condouris, Meyer & Tager-Flusberg, 2003; Luyster, Lopez & Lord, 2007; Scarborough, 1990; Schwartz, 2009). In comparison, little is known about language development in deaf children with additional disabilities, specifically how any of these disabilities affects vocabulary development over and beyond the effect of their primary hearing deficit. This seems surprising in light of the large number of deaf children with additional needs, including behavioral, cognitive, social, and other challenges who represent a unique target group for examining theories of language disorder because of the modality used for language production (gestural/manual) and language perception and processing (i.e., visual). Few studies are available that have looked specifically at this sub-group although there seems to be a consensus that deaf children with motor or sensory impairments including poor vision or cerebral palsy, as a group, show lower overall performance, compared to deaf peers without any additional needs (Allen, 1989). More investigations of deaf children with additional needs could contribute significantly to the field of deaf educational research and improve our understanding of language development in general.

One promising new area of research is the identification of specific language impairment (SLI) in deaf signing children (Mason, Rowley, Marshall, Herman, Atkinson, Woll & Morgan, 2010; Quinto-Pozos, Forber-Pratt, & Singleton, 2011). These are children who acquire sign language with great difficulty relative to their peers, despite adequate exposure to sign. Initial studies in BSL have revealed that these individuals have severe difficulty with sentence comprehension and production (Mason et al, 2010), subtle word-finding difficulties (Marshall, Rowley, Mason, Herman & Morgan, in press) and subtle difficulties repeating nonsense signs (Mason et al, 2010). However, there has not yet been a complete characterization of the language abilities of this group, including their vocabulary.

One of the reasons to explain the lack of research on deaf children with additional needs is that sign language research is still a very young field compared to spoken languages. This is of particular relevance in the context of developing language tests for deaf children as only a few signed languages have been studied in enough depth to enable standardization and norming of such tests along with the limited data that has been collected from a representative sample of deaf native signers (Johnston, 2004). Due to the small size of this group (5-10% of the deaf population) and their wide geographic distribution, which makes access difficult, research is very time consuming.

While the notion of the native signer is central to linguistic research on sign language, its role seems less critical in educational research where the primary focus is on the challenges resulting from the high diversity within the group of deaf children with hearing parents. Although the need for normative samples is understandable for the reasons pointed out, the demographics of many signing populations outside the USA (Costello et al., 2008; Johnston, 2004) make the collection of such samples near to impossible due to the small size of these populations and their widespread geographical distribution. Other factors that may affect the collection of demographic information include the lack of Deaf schools and a well-established Deaf community in some countries where sign language has not been officially recognized as a language. In this context, Costello and colleagues (2008) raise the interesting question what should be done when there are not enough deaf individuals that meet the standard requirements for native signers (e.g., deaf parents, strong affiliation with the Deaf Community), as may be the case in many countries outside the US and Europe. A related issue presents itself with regard to the considerable number of deaf individuals with additional disabilities, which also include families with (a) deaf parent(s). This leads to the general question, what should be considered as a normative sample for research including deaf individuals, which will be discussed in more detail in this paper. As we will argue, due to the small number of native signers, it may be necessary to consider treating the variable signing experiences seen in the majority of deaf language users as normative. We shall return to this point later.

Assessing Different Levels of Vocabulary Knowledge

With the exception of the adapted MacArthur Communicative Development Inventory for BSL (Woolfe et al., 2010) which targets language in preschoolers, there is currently only one published test developed specifically to assess deaf children's vocabulary in sign language, namely the *Prüfverfahren zur Erfassung Lexikalisch-Semantischer Kompetenz* (*PERLESKO)* (Bizer & Karl, 2002a, 2002b). This assessment is a receptive vocabulary test for German Sign Language (DGS), which assesses meaning recognition skills. The PERLESKO is normed for deaf children between 7-13 years, and can be used to assess individuals' comprehension skills in three language modalities, i.e. DGS, spoken, and written German. With the exception of one empirical study (Wildemann, 2008), little information about this test has been published.

While other vocabulary instruments exist, these are usually part of larger sign language assessment batteries that focus on a number of different grammatical features. The contributions of these test instruments to the field of sign language assessment is unquestionable, although all of them share the same 'limitation' with regard to vocabulary in that they only measure one level of vocabulary knowledge, mainly form recall (being able to generate a sign from seeing a picture prompt) or meaning recognition (being able to select the meaning for a sign from a set of four pictures). These limitations motivated a previous study of ours (Mann & Marshall, in press) as part of which we developed a set of vocabulary tasks to assess different levels of deaf children's vocabulary knowledge in BSL, namely form recall, meaning recall, form recognition and meaning recognition. One of the advantages of having an assessment that provides more detailed information about a child's different levels of vocabulary knowledge is that this information can be used to guide intervention and make it more effective. For instance, a child, who is not able to recall a sign when prompted by a picture (form recall) might be able to produce another, meaning related sign when presented with the target sign (meaning recall), recognize the target sign when presented in a set of responses (form recognition), and/or recognize its meaning when presented with the target sign and a set of picture responses (meaning recognition). The distinction between recall and recognition is important as it describes the depth to which the mapping between form and meaning is probed: a learner who can recall the meaning or form of a sign is also likely to successfully recognize that meaning or form when presented with a set of responses. Equally, if a learner successfully recognizes a sign but is unable to recall it, this suggests a weaker mapping than if the sign can be both recognized and recalled. By making this distinction clinicians/practitioners can avoid working on skills that already exist and instead acknowledge any such existing skills and incorporate them into more suitable intervention measures.

After findings of a previous study (Mann & Marshall, in press) with a group of strong signers showed that the BSL vocabulary tasks we developed successfully distinguish between deaf children's levels of vocabulary knowledge, our aim for the present study was to investigate how a more varied population of signers, including those with hearing parents and/or additional needs, would perform on these tasks.

The current study

In this paper we present new data on deaf children's receptive and expressive vocabulary knowledge in BSL from a group of deaf children aged 4-17 years with different language learning backgrounds, including deaf children with hearing parents and/or additional needs. We compare the performance of these students to the children with strong signing skills who took part in the pilot study reported in Mann & Marshall (in press). In addition, we investigate the relations between deaf children's vocabulary performance and a number of background variables that are likely to affect deaf children's language development, namely age, number of deaf family members, onset of signing, and presence of an additional disability. We use these data to assess the effects of some key demographic/child variables on deaf signing children's vocabulary, and discuss findings in the relation to the meaning of 'normative' data and samples for this heterogeneous population.

The focus of the first part of the paper is to discuss the advantages of critical range testing for language assessment and include a systematic comparison between this and a more traditional scoring system used in our pilot study. Critical range testing is commonly used in many standardized vocabulary assessments (e.g., PPVT, EOWPVT). It refers to the establishment of basal and ceilings sets- where basal / entry point are the number of correct responses on a test required to find the 'starting point' for a child and ceiling / test-terminating point are the number of incorrect responses that let the administrator know when to end the test. These may be consecutive responses or responses within a set of items that are defined during the test developmental phase. In our case, the basal set was defined as one/no incorrect response in the first block of 10 items and the ceiling set was defined as 6 incorrect answers in a block of 10. One of the advantages of critical range testing is that it avoids the need for participants to be presented with the full set of test items. Instead, participants are presented with just a subset of items, namely those that are appropriate for their age group.

Having established a workable scoring method, the second part of the paper present new empirical data on lexical knowledge of BSL by deaf children with different language learning backgrounds. We investigate some of the factors (namely chronological age, signing age, number of deaf relatives[1], and the presence of additional disabilities expected to predict variability on the test, embedded within the discussion of what should constitute a normative sample in such a heterogeneous population.

In the third part of the paper, we then deal with the issue of additional disabilities, given that these are so common in the deaf population, and there's a very obvious issue of whether they should be included in a normative sample. In this context, we present different language learner profiles and discuss why heterogeneity among children with additional disabilities makes them difficult to treat as one group.

Methods

Participants:

A total of 67 (37 males/ 30 females) deaf children, age 4;6-17;8 years (M = 11;11 yrs, SD =3;6) were tested in the pilot and current studies (see Table 1 for demographic characteristics of the children who participated in this study, divided in 3 groups).

Insert Table 1 here

[1] We select number of deaf family members as those children who have at least one deaf relative (e.g., mother, father, sibling) and would be generally expected to have more experience of signing and therefore to have better signing skills (see Braden, 2010, for a discussion of differences of within-family environments)

Building on a pilot (Mann & Marshall, in press) that we had previously conducted with a small group (N=24) of strong signers[2], the sample for the present study included children with differing BSL skills and language learning backgrounds as well as children with additional needs. As in the pilot, student background information was collected through an online questionnaire collecting information on degree of hearing loss, family history of deafness, home communication mode and preferred communication mode, age of onset of signing, and the presence of additional disabilities (as these could potentially affect BSL learning). This questionnaire was completed by the teacher and/or speech language therapist. Hearing loss for the 43 participants ranged from severe (N=7) to profound (N=35) and was moderate in the case of 1 participant. Two of these children had at least one deaf parent, another seven had one or more deaf siblings (including one of the children with a deaf parent), and three had a distant deaf family member, e.g., aunt, uncle, grandparent. Onset of signing ranged from birth to 14;4 years (M = 4;5 yrs, SD = 2.82). Responses to the question "please specify who the child learnt to sign from" included parents (N=12), relatives (N=3), friends (N=1), school (N=33), or other (N=7; e.g., Communication Support Worker). Eighteen children had additional disabilities, which included arthritis, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), Charge Syndrome, Cerebral Palsy, dyslexia, language processing disorder, right-sided hemiplegia (and epilepsy), Usher Syndrome, verbal dyspraxia, visual impairments, and Worster-Drought Syndrome (see Table 2 for distribution of disabilities across participants). Because the range of additional disabilities

[2] These children were identified based on their proficiency in receptive and productive BSL skills by a fluent signer, who was either a deaf teacher or a hearing teacher with deaf parents (CODA).

is so diverse, we did not to divide children by type of disability but analyzed them as a single group.

Insert Table 2 here

Participants came from eleven schools and units serving deaf children in the UK[3], ranging from primary school level to Community College. With the exception of two children from oral and mainstream programs with English as the main language, all participants were in programs that used both English and BSL as means of communication and instruction. With regard to their day-to-day communication, most children (N=34) stated sign language as their preferred means of communication, identified as BSL by 26 of the respondents; other choices included spoken language (N=6), Sign Supported English[4] (SSE) (N=4), and Total Communication[5] (TC) (N=1) or a combination (N=3). Eight of the children had a Cochlear Implant.

The BSL-VT tasks

Three vocabulary tasks were administered, one of which was an expressive skills task (form recall) and two receptive skills tasks (form recognition and meaning recognition).

Receptive vocabulary skills were assessed in two ways:

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[3] Although known by many different names across the UK, a unit/resource base may be defined as specialist provision within a mainstream school. Some resource bases for deaf children may be attached to a special school catering for another primary need e.g. for learning difficulties.

[4] SSE is a form of manually coded language that is common in the UK, which borrows signs from BSL and uses them in the order that the words would be spoken in English.

[5] Total Communication is understood as an instructional approach to Deaf Education that makes use of a number of modes of communication such as signed, oral, auditory, written and visual aids, depending on the particular needs and abilities of the child.

Form Recall

In this task, participants see an image and are asked to produce the corresponding BSL sign. The test administrator judges the correctness of the sign with regard to semantic accuracy (NOT phonological accuracy) by selecting one of four scoring choices ('Correct', 'Partially correct', Wrong/Different sign', and 'Don't know') on the screen. As an additional means of determining the accuracy of their judgment, the test administrator manually enters the English gloss for each sign into a textbox on the screen (see Figure 1).

Insert Figure 1 here

Form Recognition

In this task, participants are presented with a stimulus image and four signs. Their task is to select the sign that best matches the image by using the mouse to click a radio button below the video (see Figure 2).

Insert Figure 2 here

Meaning Recognition

In this task, participants are presented with a stimulus sign and four images on their screen and have to select the image that best illustrates the meaning of the sign by clicking the radio button below the image with the mouse (see Figure 3).

Insert Figure 3 here

Each task consisted of 120 items and took between 5-25 minutes to administer, depending on the skills of the participant. All children completed the tasks once.

Test Format

The BSL vocabulary tasks assess understanding of different levels of word knowledge. All of the tasked were web-based. One of our main criteria for using the internet was the combination of multiple sources of information, including images, videos, and text to facilitate retention of the target vocabulary. This is a move away from more traditional formats where the target sign/word appears on a different screen and cannot be replayed. In contrast, our participants were presented with both stimulus and response on the same screen and were allowed to replay a video as often as they like before selecting a response. Another reason for choosing this medium was its easy and immediate access for teachers and Speech Language Therapists, making the process of test administration much less time consuming. In comparison to other test formats, i.e., use of pre-recorded test items on video combined with a test booklet, our web-based approach does not require the test taker to write the answers in the booklet from where they are then entered into the computer by the test administrator; instead, all responses provided by the test taker are automatically saved onto an external web-server. This also includes any scores that are entered 'live' during administration of the expressive skills tasks, which we discuss in greater detail later in this paper.

A PHP[6] script was written to allow the administration of the tasks from the web. This program/script includes various pages with PHP and HTML files, which enable the user to navigate back and forth between pages, play videos, select answers by clicking on radio buttons, and/or to open/download pdf files (e.g., tutorials). It was developed by an external collaborator, MicroActive. The website, itself, was password protected. All schools were provided with the general login information to access the website and also received unique user codes for each participating pupil. This code had to be entered in order to access any of the four tasks and was stored in a database along with the results. The database was automatically updated every time the test was administered. It could be viewed either as webpage or downloaded as Excel worksheet.

Procedure

The administration time for each task was about 5-25 minutes depending on the participant's age and skills. Prior to the beginning of each task, participants saw a video with pre-recorded instructions in BSL on their computer screen[7]. Next, they were given time for practice on two items during which they could ask questions. The tasks were administered over the course of two weeks, with two tasks administered during week 1 and one task during week 2. All participants completed the three tasks in the same order (i.e., form recall, form recognition, meaning recognition). This order was chosen to

[6] PHP is commonly understood as a general-purpose scripting language originally designed for web development to produce dynamic web pages.

[7] Located below the video with the pre-recorded instructions in BSL, participants had the option to read the instructions in English, where preferred. Notwithstanding their language preference, all participants were shown the BSL instructions first.

minimize, where possible, learning effects. For the form recall task, prompts (e.g., what is this? what is s/he doing? how does s/he feel?) were used, where appropriate, to focus the participants' attention. To minimize fingerspelt responses or responses in phrase format, participants were encouraged during the practice to respond with a single sign.

The tasks were administered via the internet by a teacher of the Deaf or a Speech and Language Therapist at the school. Administrators received training in form of 3 tutorials, which they had to complete before using the test. In addition, they had to be fluent BSL signers (BSL level 2 or higher) in order to be qualified to administer the test. Each participating school received the link to the test website by email along with the login information for pupils. Once on the website, a test administrator had direct access to the tasks and also could download a number of useful documents, which included a sheet with frequently asked questions, a booklet with still frames of each target sign, an item list, and a scoring template. Additional information was provided on the type of browser/media player (Flashplayer) necessary to successfully play all videos.

Upon receiving the access codes and unique user IDs, test administrators were instructed to go through all tutorials and to download the booklet with target signs in order to familiarize themselves with the administration procedures and to identify any potential regional variants. Where requested, test administrators received additional assistance and guidance by email/phone from the first author. All tasks were administered individually at each school.

Scoring

For the receptive skills tasks, all answers provided by participants were matched against a pre-specified marking key and automatically scored as correct (1) or incorrect (0). These scores were saved in a database on the web-server. For the productive skills task, participants' responses were manually entered by the test administrator in a scoring form, which appeared together with the stimuli on screen. Four scoring choices were provided. The coding scheme consisted of "correct sign", "partially correct sign", "wrong sign/different sign" (i.e. incorrect), and "do not know" responses, which appeared as "CS", "PCS", "WS/DS" and "DNK" respectively so that the participant did not know whether their response was correct or not, and would therefore not become less motivated. A response was coded as "correct" and scored as 1 if the participant demonstrated the ability to provide the expected BSL sign to name the target item and as "partially correct", scored as 0.5, if the participant supplied a sign that was outside the immediate range of expected answers, yet suggested that they knew the meaning of the target. In addition to scoring each response, the gloss for each sign was entered into a textbox below the score choices. Inter-rater reliability on the judgment of responses was carried out, with a hearing fluent signer coding the responses of seven of the children, in comparison with the teachers' coding. Mean reliability was 91% for the form recall task.

Critical Range Testing

For the test administration, we adapted the Critical Range Testing approach, which is commonly used in some of the major vocabulary assessments, e.g., Peabody Picture Vocabulary Test (PPVT), Expressive One Word Picture Vocabulary Test (EOWPVT). Following this approach, only a subset of consecutive items, or critical range, needs to be administered, assuming that items are arranged in order of difficulty. The critical range varies for each participant. It begins with items that are considered very easy for the participant and ends at a point when the participant answers a predetermined number of items incorrectly. In our adapted version, the range began with a series of nine correct responses (in a set of ten), the basal, and ended with a series of six incorrect responses (in a set of ten), the ceiling. This approach is based on the idea that an individual who makes several consecutive correct responses can be assumed to also correctly answer the preceding items. Consequently, these earlier items do not need to be administered. Similarly, an individual who answers several items incorrectly can be assumed to also miss subsequent items, which increase in difficulty (EOWPVT Manual, Brownell, 2000). Similar to standardized vocabulary test for spoken language, the item sequence of our test was driven by sign frequency, and also by the age appropriateness of the signs for our target group, i.e., children between 5-15 years. Determining the age of acquisition for sign language is an important issue for constructing a vocabulary test (Johnston, 2012) with particular regard to the lack of frequency lists. We addressed this issue by using a variety of sources for selecting our items, including a norming study of BSL by Vinson and colleagues (2008), some of the most commonly used standardized vocabulary tests for spoken language, as well as feedback from deaf/hearing teachers of the Deaf.

In order to establish the basal level for a participant, testing began at an item level that was one year below the participant's chronological age. This was done to minimize any difficulties for any participants, whose vocabulary may not age appropriate, which, in case of the targeted population, happens frequently. In cases where the administrator did not establish a basal of nine correct responses within one item set, s/he had to return to the first item administered and work backward until basal had been established or the first item of the test administered.

The decision to use Critical Range Testing was made to reduce time for administration and make the test more practicable for use in an educational setting. To explore the feasibility of this approach, we applied a systematical comparison between this and a more traditional scoring system used in a pilot study, as we describe in the results section.

Results

We carried out the following analyses:

1. For the pilot group of children (from Mann & Marshall, in press) we compared the full range of scores reported in that study to scores calculated under Critical Range Testing. Our aim was to investigate how comparable the two scoring systems are. If the two scoring systems were indeed comparable, then this would allow us to do two further analyses:
2. We compared the scores of two groups of children newly tested for the present study - those without additional disabilities and those with additional disabilities – to the group of strong signers who took part in the pilot.
3. We combined the three groups for an analysis of the factors that are predicted to affect performance on the three vocabulary tasks: chronological age, signing age, number of deaf relatives, and the presence of additional disabilities.

Comparison of vocabulary performance according to new vs. old scoring scheme

First we checked that scores obtained under the new method of scoring (i.e. the critical range testing method) and those obtained under the old method (i.e. used in Mann & Marshall, in press) were highly similar. For this analysis we used just the pilot group, as these were the only children who had attempted the full set of items. Each child had two scores for each vocabulary task: the full raw score, and the new score calculated under Critical Range Testing (i.e. after a basal and ceiling set had been established).

In order to test the comparability of the two scoring systems for each of the three vocabulary tasks, we calculated Cronbach's alpha. All values were very high: for meaning recognition, α=0.98, for form recognition, α=0.95 and for form recall, α=0.98. We concluded that the Critical Range Testing method was reliable and made minimal impact on the rank ordering of scores. We therefore proceed with the analysis on the new groups of participants using the new scoring method.

Comparison of vocabulary performance across the three groups

In this next analysis we compared the scores of 2 new groups of children - those without additional disabilities (N=25) and those with additional disabilities (N=18) – to the group of strong signers who took part in the pilot. Although the children in these groups were older than those in the pilot group, a one-way ANOVA for chronological age revealed no significant group differences. $F(2,66) = 1.00$, $p = 0.373$. We were therefore able to directly compare the performance of the three groups on the three different vocabulary tasks. In order to do this, we carried out a series of one-way ANOVAs on scores, with group (pilot, new without additional disabilities, new with additional disabilities) as the between group factor. For none of these 3 tasks were there any significant effects of group membership on score: for meaning recognition, $F(2,66) = 0.137$, $p = 0.872$; for form recognition, $F(2,66) = 0.074$, $p = 0.929$; for form recall, $F(2,66) = 0.344$, $p = 0.710$. Figures 4-6 illustrate the individual scores for the three tasks, and demonstrate the strong relationship between score and age, but also the variability in scores at each age. The group means are shown in Table 3. The three data points that are numbered (1-3) in each figure represent children whose individual data will be discussed in more detail later, and Child 3 represents an outlier whose data were excluded from the group means.

Insert Figure 4 here

Insert Figure 5 here

Insert Figure 6 here

Insert Table 3 here

*Analysis of predictor variables of vocabulary performan*ce

In our next analysis, we combined all 3 groups in order to investigate the factors that affect performance on the 3 vocabulary tasks. The four factors of interest were: (1) chronological age, (2) signing age (calculated as chronological age in months minus the age in months at which the child was first exposed to BSL), (3) the number of deaf family members, (4) the presence of additional disabilities. We present correlations between these factors and scores on the three vocabulary tests in Table 4. Pooling the data meant that because three children from the pilot had also been identified with additional disabilities (1 child had suspected dyslexia, 1 had suspected ADHD, and 1 had no specified diagnosis), there were now 21 children with additional disabilities. Due to missing data from some of the participants with respect to signing age (missing N=9) and the number of deaf relatives (missing N=4), the sample size is not the full 67 for all correlations.

Insert Table 4 here

Not surprisingly, age was very strongly correlated with scores on all three tasks – as children get older, their vocabulary knowledge improves. Signing age (i.e. the amount the time a child has spent signing) also correlated strongly with vocabulary scores, but signing age is itself highly correlated with actual chronological age – children who have spent longer signing tend to be older. The two other factors - presence versus absence of a disability, and the number of deaf relatives – did not correlate significantly with scores on any of the three tasks. However, the number of deaf relatives was negatively correlated with age – the younger children in our sample were more likely to have a deaf relative.

In order to determine the independent contribution of the four factors upon vocabulary scores, we used three multiple regressions, which all took the same form. We entered age in the first block, and then signing age, the number of deaf family members, and the presence of additional disabilities in the second block.

For meaning recognition, age on its own predicted 56.2% of the variance in scores (Beta = 0.750, $t = 8.409$, $p < 0.001$). Adding the additional three factors resulted in a model that accounted for only an additional 2.5% variance in scores, with no one factor emerging as a significant additional predictor. For form recognition, age on its own predicted 52.8% of the variance in scores (Beta = 0.727, $t = 7.842$, $p < 0.001$). Adding the additional three factors resulted in a model that accounted for an additional 3.5% variance in scores, and again no one factor emerged as a significant additional predictor. For form recall the picture was slightly different. Age on its own was a significant predictor of 56.1% of the variance in scores (Beta = 0.749, $t = 8.382$, $p < 0.001$). The three additional factors accounted for a further 7.5% of variance, and this time the number of relatives (but neither of the other factors) emerged as a significant predictor (Beta = 0.235, $t = 2.309$, $p = 0.025$).

Hence, chronological age is, unsurprisingly, a significant (indeed, the most significant) factor in performance on all tasks. One other factor – the number of deaf relatives – only become statistically significant for the form recall task. Signing age is presumably too highly correlated with chronological age (see Table 4) to account for additional variance in vocabulary scores once chronological age was taken into account, and the presence of additional disabilities has no effect on scores for any of the three tasks. We will discuss possible implications of the findings later.

Participant Profiles

In order to give the reader a more in-depth view of the data, we present in this section detailed profiles of three of the children and their scores on the BSL-VT. These children's scores relative to the rest of the group can be seen on the scatterplots in Figures 5-7, and their scores can also be compared to the mean score and range for their age band in Table 5.

Insert Table 5 here

Child 1 is a female aged 10;10, with profound hearing loss that was detected at 20 months, and which had an age of onset of 14 months. She has a hearing aid in the right ear and a cochlear implant (CI) for the left ear. There is no history of deafness in her family. She learned signing around the age of 2 years from/with parents and a communication support worker. Home communication is in Total Communication, and her preferred mode of communication is Sign Supported English (SSE). Additional to her deafness, Child 1 has been diagnosed with right-sided hemiplegia and epilepsy. She entered regular primary school at age 4, and attends an integrated Hearing Impaired Department. The mode of communication used at school is Total Communication. Her teacher rated her signing skills as good. Child 1's scores are higher than average for her age: she scored 119 for meaning recognition, 113 for form recognition, and 111 for form recall. Her only error on the meaning recognition task was POLLUTION, and she did not get this item correct on the form recognition or form recall tasks either, indicating that the item was not known. She was acquainted with other signs however, even though they were not established. For example, she recognized the forms of the signs DISGUSTED and PARIS in the form recognition task, but was not able to produce the signs correctly in the form recall task. Conversely, she produced the signs BULLY and LIGHTBULB in the form recall task, but was unable to recognize them in the form recognition task.

Child 2 is a female aged 8;2 with profound hearing loss from birth that was diagnosed at the age of 3 years, and she started signing at 3 years old. She wears hearing aids in both ears and has no CI. She has a history of deafness in her family, with 2 deaf relatives (a younger sister and a grandmother). Home communication is English and BSL. Child 2's preferred means of communication is BSL, and her signing level was rated by teacher/SLT as intermediate (2). She has no additional disabilities. She entered primary school at age 3. The school has a hearing impaired resource, where the communication policy is bilingual. Child 2's scores are: 87 for meaning recognition, 83 for form recognition, and 75 for form recall, which places her close to the mean for her age. Some of these items, such as MIRROR she got right across the 3 tasks, demonstrating established knowledge. Others, such as HOSPITAL, she did not get right on any of the 3 tasks, and we can conclude that these items were unknown. As with Child 1, there were items for which she had partial knowledge, but unlike Child 1, who had scored very highly on the meaning recognition task, Child 2 had items that she could not recognize in the meaning recognition task but scored correctly on for both the form recognition and form recall tasks, such as HORSE, or scored correctly on for just one of those tasks.

Child 3 is a male aged 12;8 with profound hearing loss that was discovered at birth. He received cochlear implants aged 3. He is from a hearing family and has been learning BSL since he started school aged 4. His teacher rated his signing skills as good. He has autism and learning difficulties (no IQ score is available). His scores of 45 on the meaning recognition task, 49 on the form recognition task, and 48 on the form recall task put him well below the expected range for his age. Of the 50 items that he attempted across all 3 tasks (because the use of basal and ceiling sets meant that children did not necessarily attempt every item), for only 30 of those 50 did he score correct for all tasks. In other words, for 20 of those items he demonstrated only partial knowledge.

Discussion

This study investigated BSL vocabulary in deaf children between the ages of 4-17 years. We introduced a new approach to assessing sign language vocabulary, using three tasks that test the same set of items in order to differentiate between unknown, acquainted and established signs. We also investigated how performance across the three tasks relates to chronological age, signing age, number of deaf family members, and whether the child has any additional disability. By testing children with a wider range of signing experience and a sizable number with additional disabilities, we aimed to go beyond our pilot study, which had been carried out with strong signers (Mann & Marshall, in press), in order to contribute to a discussion of what might constitute a normative sample for sign language assessments.

With forty three new deaf signers (25 without and 18 with additional disabilities) added to our original pilot sample of 24, we were able to show that, not surprisingly the three vocabulary tasks are sensitive to chronological age: as children get older, they perform better on the tasks.

Few deaf signers receive signing input from birth in their family environment. The majority, who are born to hearing parents, receive delayed sign input, and consequently the amount of time for which they have experienced sign language is not the same as their chronological age. We investigated whether “signing age” (the amount of time for which the child had been learning sign) predicted vocabulary scores independently of chronological age. It did not, presumably because over the wide range of ages tested in this study signing age and chronological age were highly correlated. Also related to the sign language input that children get is whether they have deaf relatives. We found that the number of deaf relatives that a child has is, independently of signing age, a significant predictor of performance on the form recall task (but not of the receptive vocabulary tasks).

We would not wish to argue that the lack of significant impact of signing age and the number of relatives on receptive scores tasks means that signing experience is not important for vocabulary comprehension. Signing age was significantly correlated with vocabulary, but it didn’t explain any additional variance once chronological age was taken into account. Our non-significant findings results could be due to the wide age range of children (perhaps these factors are particularly important in the early years when the majority of the child’s communication experience will be at home). Certainly, the finding that the number of deaf relatives has a significant effect on form recall shows that signing experience does have a significant effect of vocabulary acquisition. We likewise would not wish to interpret the lack of a significant influence of additional disabilities on vocabulary scores as meaning that there are no disabilities have an impact on vocabulary acquisition. We had a small number of children in our study – 2 with dyslexia, 4 with autism and 1 with social communication difficulties – whose disabilities might reasonably be expected to impact on their vocabulary acquisition, given that we know this can be the case in spoken languages (Schwartz, 2009).

For example, Child 3, whom we profiled at the end of the Results section, had below expected levels of performance across the three tasks, and his autism and learning difficulties may well have contributed to his poor vocabulary (as has been reported for spoken languages: Condouris, Meyer & Tager-Flusberg, 2003; Luyster, Lopez & Lord, 2007; *inter alia*). We would be unwise to speculate too far on the basis of one child's profile, but we notice that Child 3 does not show the pattern of worse performance on the form recall task compared to the two recognition tasks that was reported by Anonymous (in press) and which is also seen among our participants in Table 3; this unusual profile is consistent with reports of autism in spoken languages, where the delay in receptive vocabulary is greater than the delay in expressive vocabulary (Charman, Drew, Baird, & Baird, 2003; Hudry et al, 2010). Studies which assess vocabulary development in deaf children with a wide range of additional disabilities might contribute important information about (the) possible effects of disabilities on word learning that are most common within the group of deaf language users. The BSL-VT might be particularly valuable in this regard, as it enables identical items to be compared across more than one task, and hence unusual profiles to be identified.

However, the lack of a significant effect of additional disabilities in any of our analyses suggests that for deaf children as a whole this particular factor is not as important for vocabulary acquisition as other factors might be, specifically the impact of their primary deficit of hearing loss. This is an important finding given the large number of deaf children with additional disabilities in the UK (Rowley et al., in prep.), which is also reflected in our sample. As this sub-group, which constituted nearly a third of our sample, has been generally excluded from research/assessment, our findings suggest more flexible selection criteria for research with deaf participants. Teachers, on the other hand, should maintain high expectations in the BSL vocabulary development of those deaf children they teach who have additional disabilities. In this context, it would be interesting in a follow-up study to look at the existing BSL receptive (Herman et al., 1999) and productive (Herman et al, 2004) BSL assessments to create a profile for each child and explore possible effects that additional disability may have with these assessments.

In summary, other than age, the factors that we investigated had only marginal effects on performance. These findings have potential implications for how normative samples are selected in the development of language tests. Given that large numbers of deaf children have late exposure to sign and/or have additional disabilities, we argue that, at least for tests of vocabulary, test developers should take a pragmatic approach and consider including this wider range of children in their normative samples.

While we understand the importance of choosing deaf children with deaf parents and no additional needs as target group for linguistically driven research on sign language and to establish norms (for standardized tests), we wonder how practicable this approach is for research in educational settings with the aims to inform intervention and/or instruction.

More than that, taking into consideration the size constraints of deaf populations in many smaller countries (e.g., Costillo et al., 2008; Rowley et al. in preparation; Johnston, 2004) the feasibility of this approach seems highly questionable. In addition, recent research on specific language impairment (Mason et al., 2010; Quinto-Pozos et al., 2011) indicates that the occurrence of additional disabilities is not limited to deaf children with hearing parents but also can be found within the group of deaf children from deaf families.

In light of the considerable heterogeneity that characterizes today's young deaf language users, which –among other factors- is affected by the notable numbers of individuals with a cognitive, psychological, and/or physical disorder in addition to their hearing loss, the provision of support that is appropriate for each child's unique needs has become even more challenging. At the same time, the extent to which each of these disorders may affect a child's successful language development is likely to vary.

By advocating the inclusion of the group of deaf children with additional disorders in research on vocabulary assessment, we nevertheless urge caution. Clearly, the identification and careful investigation of any existing needs in addition to hearing loss and how these needs may affect vocabulary development (based on what is known from the literature on spoken language) are important first steps. However, we believe that a change in researchers' perception of deaf children with additional disabilities is necessary and argue against a "no-additional-disability-at-all" approach when selecting a sample, which no longer seems representative of young deaf language users and may considerably underestimate the existing language skills of many individuals with another disability.

With respect to the BSL-VT itself, one of its main advantages is that it can be used in two ways, thereby enabling the test administrator to determine the level of detail of information s/he requires about the test taker's performance. For instance, if a teacher starts the test with the most difficult task, form recall, and finds that the child scores poorly, s/he can investigate why that is by administering the items that the child fails at this task in the meaning recognition and/or the form recognition task. If the child shows knowledge of these items in the form recognition task, it would mean that s/he needs more production practice. However, if the child also fail to show knowledge of the items in one or both comprehension tasks, then it would not be surprising that s/he couldn't produce them. Using the test this way, the BSL-vocabulary test provides teachers/SLT's with a more general overview of a child's knowledge of the target signs. By working the child through all 3 tasks and using the means +/-1SD bands provided in Table 5, they can get a rough picture of how the child fits into age expectations.

In addition, however, teachers can use the test in an alternative way by administering each of the tasks separately, starting with the form recall task which is considered the most difficult and then continue to also administer the form recognition task followed by the meaning recognition task where necessary. To further facilitate this second approach in the future, it is planned to develop a fully computer adapted version of the BSL-vocabulary test as part of which any item a test taker correctly answers in the more difficult task, e.g., form recall, will be automatically removed by the computer and no longer appear in the remaining tasks to administer, e.g., form recognition, meaning recognition. In addition to greater flexibility, this will also make the test administration of all tasks significantly less time consuming as the number of remaining items to be administered becomes smaller while the test/a task is completed.

The test can be found at http://www.staff.city.ac.uk/bslvt/ and is free for schools and researchers to use. To access the test website a user name and password are required, both of which can be obtained by emailing the first author.

Conclusion

Overall, the findings from our study are consistent with evidence from research with hearing children showing that vocabulary development, specifically expressive skills, is closely bound to language experience and exposure to meaningful and consistent language input. While it is important for obvious reasons to promote deaf children's development of vocabulary in spoken language, similar efforts are needed to provide effective intervention for sign language for those deaf children, who choose to communicate in sign. One of the ways to facilitate these efforts is developing appropriate sign language assessments. However, test developers are facing considerable changes within the group of deaf language users, especially the large number of deaf individuals with additional disorders that may also include children from deaf families, who are generally considered the normative sample. These changes along with other size constraints reflected in the demographics of many signing populations outside the USA require us to rethink our approach to sign language assessment. We feel that acknowledging these changes and constraints and taking a more pragmatic approach to vocabulary assessment which allows more flexible selection criteria of the deaf research sample are important steps towards adjustment to Deaf Education in the 21st Century. This does not mean that our assessments will be less precise as a consequence. As we have demonstrated in this paper, a more nuanced approach can provide rich detail on deaf language users' developmental level of vocabulary knowledge.

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Figures and Tables

Figure 1: Example of an item of the Form Recall Task

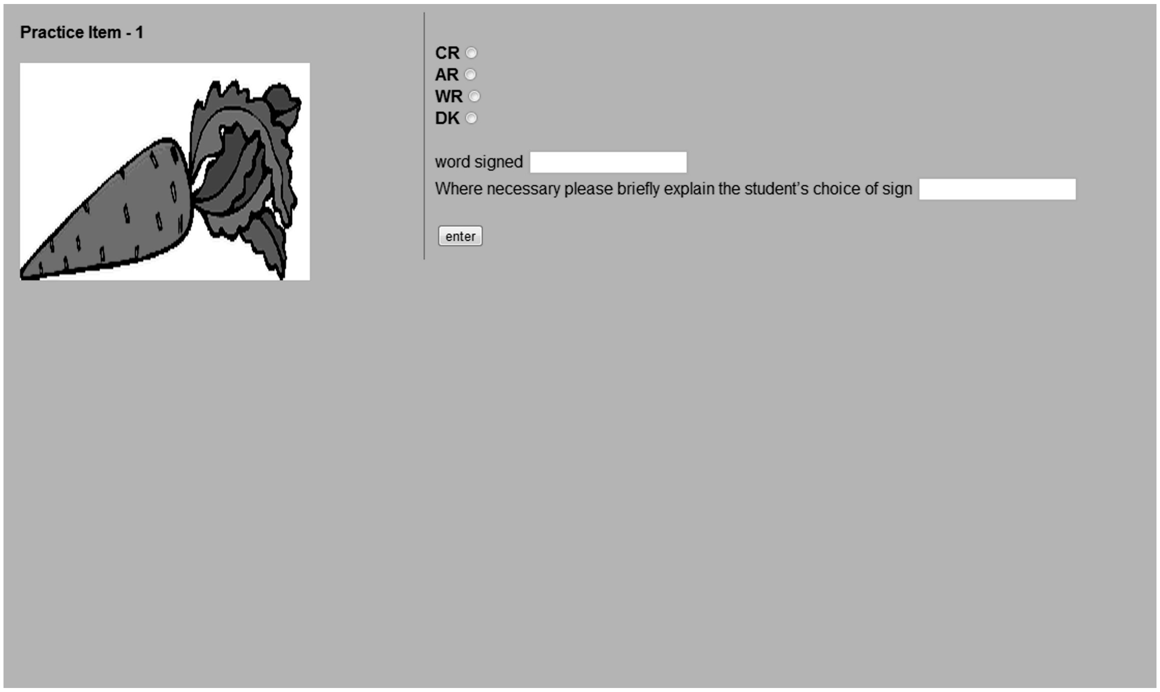


Figure 2: Example of an item of the Form Recognition Task

Figure 3: Example of a test item of the Meaning Recognition Task

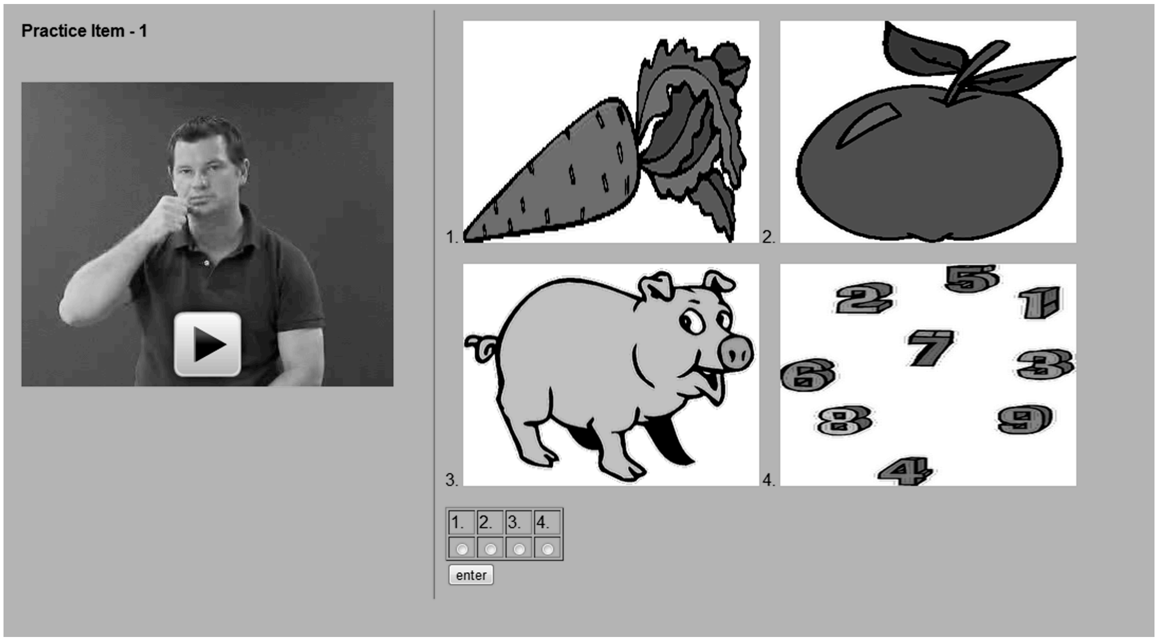
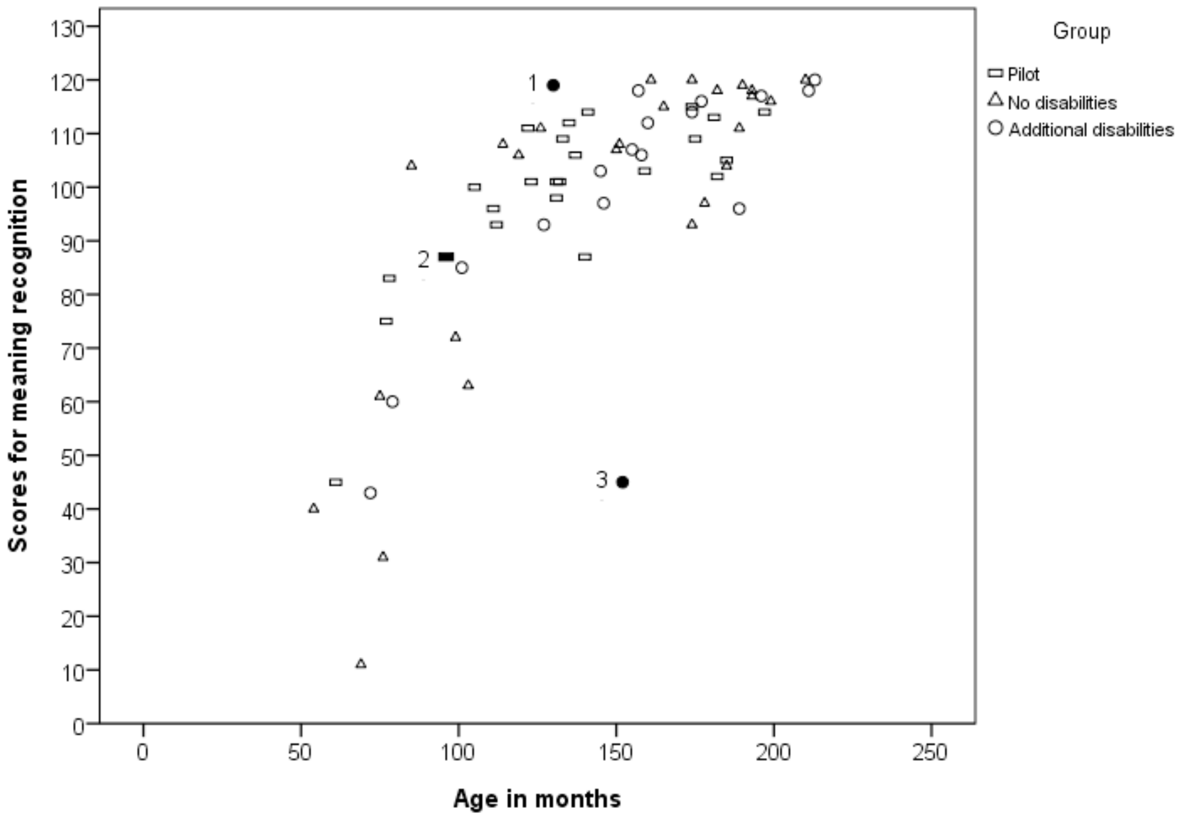
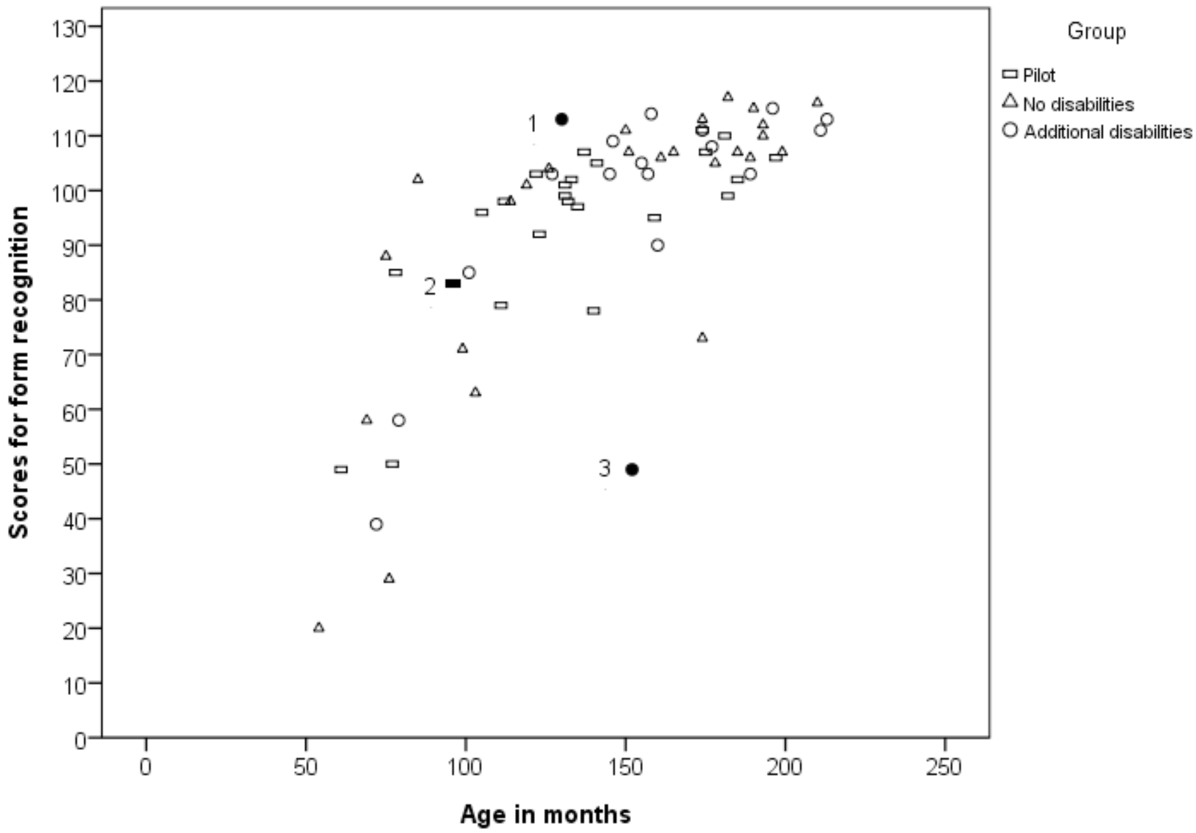


Figure 4. Scatterplot showing Meaning Recognition performance against age in months



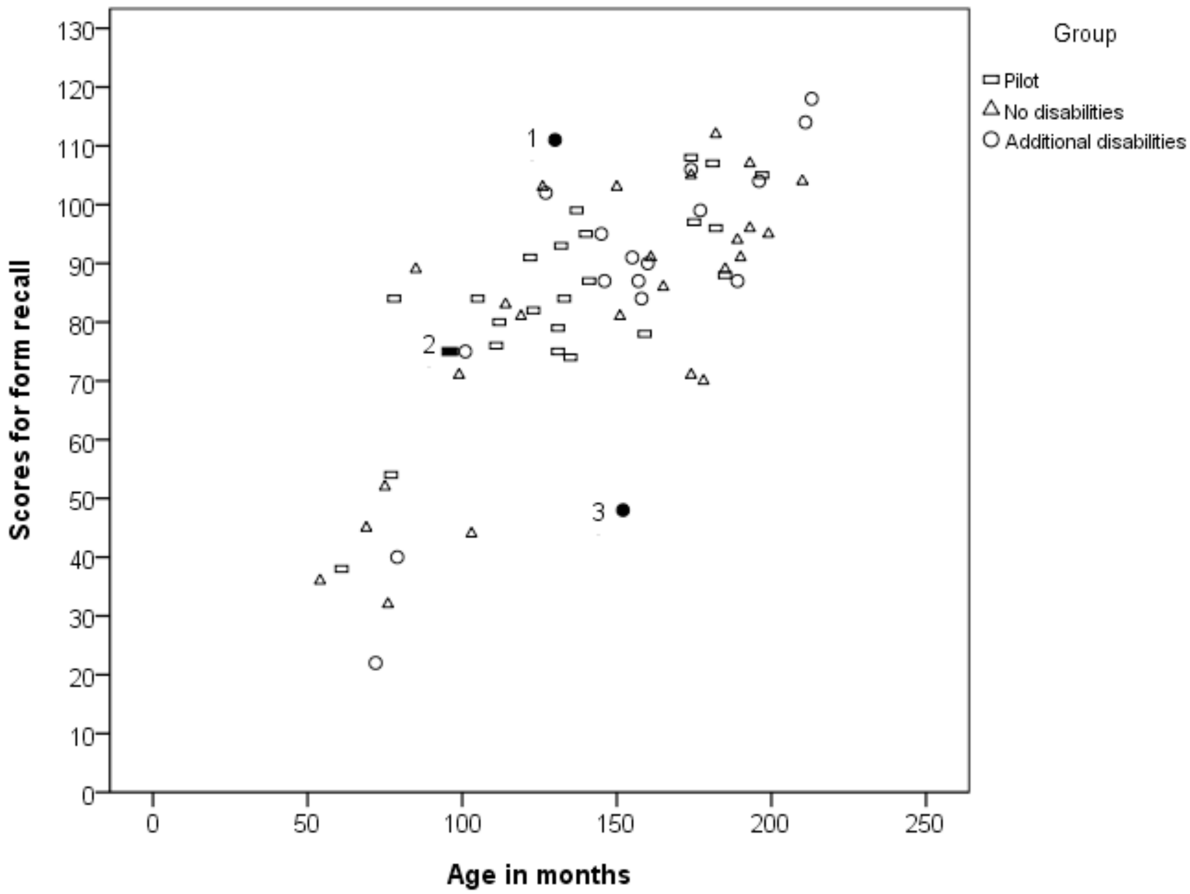
Key: Numbers refer to the individual children whose profiles are presented in the results section.

Figure 5. Scatterplot showing Form Recognition performance against age in months



Key: Numbers refer to the individual children whose profiles are presented in the results section.

Figure 6. Scatterplot showing Form Recall performance against age in months



Key: Numbers refer to the individual children whose profiles are presented in the results section.

Table 1. Characteristics of the participants (N=67)

	Parental hearing status	Boys	Girls	Deaf relatives *	Cochlear Implant	Age in months (SD)	Signing Age in months (SD)	Ethnicity
Pilot (24)	Deaf (N=7)	6	1	4	0	147 (45)	147 (45)	2
	Hearing (N=17)	6	11	7	5	129 (32)	71 (22) ^^	3
Group 1 (25)	Deaf (N=2)	1	1	1	0	139 (50)	118 (80)	0
	Hearing (N=23)	9	14	9^	3	145 (49)	104 (59)	6
Group 2: Additional Disabilities (18)	Deaf (N=0)	0	0	0	0	0	0	0
	Hearing (N=18)	14	4	1	5	152 (40)	95(31)	4

******siblings, uncle/aunt, grandfather/grandmother*

^ *missing data for 7 participants*

^^ *missing data for 3 children*

Table 2: Demographics of participants with additional needs

N (21)	Type of additional needs	Diagnosed (D) or Suspected (S)
2	*ADHD (including 1 pilot student)*	*(1xD+1xS)*
1	*Allergies, arthritis*	*(D)*
5	*ASD/social communication difficulties (one of whom also has learning difficulties)*	*(4xD)(1xS)*
2	*Cerebral palsy*	*(D+S)*
2	*Dyslexia (including 1 pilot student)*	*(S)*
1	*Right-sided hemiplegia (and epilepsy)*	*(D)*
3	*Syndromes (Charge, Usher, Worster Drought)*	*(D)*
2	*Verbal dyspraxia (one of whom also has dysphagia)*	*(D+S)*
1	*Visual impairment*	*(D)*
2	*Not specified (including 1 pilot student)*	*(S)*

Table 3: Scores for the vocabulary tasks. Each task has a maximum score of 120.

Test raw scores	Pilot group (N=24)			Group 1 (N=25)			Group 2: Additional disabilities (N=18)		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Meaning recognition	99.17	15.63	45-115	95.60	30.95	11 - 120	98.28	24.86	43 - 120
Form recognition	93.83	16.35	49-111	93.84	26.58	20 - 117	96.22	23.47	39 - 115
Form recall	84.54	15.85	38-108	81.24	23.19	32 - 112	86.67	25.99	22 - 118

Table 4. Correlations between the three vocabulary tasks and different factors

	Meaning recognition	Form recognition	Form recall	Signing age	Additional disability	Number of deaf relatives
Age	0.740 p <0.001 N = 67	0.729 p <0.001 N = 67	0.741 p <0.001 N = 67	0.679 p <0.001 N = 58	0.191 p = 0.121 N = 67	-0.280 p = 0.026 N = 63
Meaning recognition		0.907 p <0.001 N = 67	0.884 p <0.001 N = 67	0.556 p <0.001 N = 58	0.018 p = 0.886 N = 67	-0.095 p = 0.460 N = 63
Form recognition			0.890 p <0.001 N = 67	0.585 p <0.001 N = 58	0.039 p = 0.752 N = 67	-0.071 p = 0.581 N = 63
Form recall				0.640 p <0.001 N = 58	0.117 p = 0.346 N = 67	0.000 p = 0.997 N = 63
Signing age					0.030 P = 0.822 N = 58	0.068 p = 0.615 N = 57
Additional disability						-0.355 p = 0.004 N = 63

Table 5. Average scores/norms across age groups

Age band (in years)	Number of children	Meaning Recognition Mean (+/- 1SD)	Form Recognition Mean (+/- 1SD)	Form Recall Mean (+/- 1SD)
4-6	9	50 (28-72)	53 (30-76)	45 (27-63)
7-9	10	91 (76-106)	88 (74-102)	76 (64-88)
10-12*	18	105 (97-113)	102 (94-110)	91 (81-101)
13-15	21	110 (102-118)	105 (95-115)	92 (81-103)
16-17	8	117 (115-119)	111 (107-115)	105 (97-113)

*One child (Child 3 in Figures 4-6) scored so poorly that his data are excluded from these calculations.