Aided communication, mind understanding and co-construction of meaning

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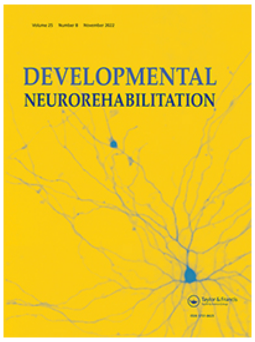

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Aided communication, mind understanding and co-construction of meaning

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ABSTRACT

Mind understanding allows for the adaptation of expressive language to a listener and is a core element when communicating new information to a communication partner. There is limited knowledge about the relationship between aided language and mind understanding. This study investigates this relationship using a communication task. The participants were 71 aided communicators using graphic symbols or spelling for expression (38/33 girls/boys) and a reference group of 40 speaking children (21/19 girls/boys), aged 5;0–15;11 years. The task was to describe, but not name, drawings to a communication partner. The partner could not see the drawing and had to infer what was depicted from the child's explanation. Dyads with aided communicators solved fewer items than reference dyads (64% vs 93%). The aided spellers presented more precise details than the symbol users (46% vs 38%). In the aided group, number of correct items correlated with verbal comprehension and age.

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Introduction

Communication can be described as a "co-constructive act, where intentionality and understanding of the other's thoughts and intentions are important components for success"[1]. Successful communication therefore requires the ability of the communication partners to take the perspective of the other.[2] Such perspective-taking involves *mind understanding*, the understanding that oneself and others form mental representations of people, things, and events.[3–7] The field of mind understanding includes several concepts, including *theory of mind*,[8] focusing on how mental states like wants and beliefs influence behavior.[9] The term "theory" reflects that the mind cannot be observed directly and that individuals have to draw inferences about the perceptions, thoughts, desires and emotions of others beyond what they can observe. These approaches focus particularly on how children form an understanding of the influences that incomplete information and false beliefs may have on behavior.[10] *Mentalizing* is described as a process that involves thinking about relations, human interaction and psychological processes in human beings.[11,12] Other researchers use the concepts "common sense psychology," "mindreading" or "social understanding."[4,13] In the present study, the tasks involving children's understanding of mind do not involve attribution of false beliefs or desires and we therefore use the general term *mind understanding*.[5,6]

The understanding of mind has been linked to language development.[10,14–16] Mind understanding is involved when inferring the communicative intentions of others. The listener's inference of the speaker´s intended meaning goes beyond mere linguistic decoding, as referential ambivalences, linguistic ambiguities, and vague and incomplete information needs to be interpreted within a contextual framework.[17] Mind understanding includes children's ability to take the listener's knowledge and perspective into consideration, that is, what relevant information the communication partner has and what information the child needs to provide in order for the communication to be successful. Delayed development of mind understanding has been related to communication difficulties, including deaf children of hearing parents[18,19] and children with specific language disorders.[20,21] Thus, children with restricted opportunities for communication may have particular experiential challenges with developing mind understanding.

Children, who have severe speech impairments due to motor impairment and rely on augmentative and alternative communication, have restricted expressive means. The speech impairments may be due to cerebral palsy, the most common cause of physical disability in childhood,[22] neuromuscular disease, or acquired brain injury.[23] Even if the children understand spoken language, their motor impairments may preclude

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the use of speech and limit the use of gestures and manual signs. For this group of children, aided communication in the form of graphic symbols and/or letters becomes their main means of expressing themselves linguistically. The graphic symbols represent the words which these children use to express themselves. Graphic systems can be pictographic, where the images resemble the person, object, or action referred to (e.g., Picture Communication Symbols,[24]) or ideographic, where the image has less visual resemblance to the category that is depicted (e.g., the Blissymbolics system.[25]) An important difference between pictographic systems and ideographic systems is that the latter are more generative, that is, they allow for more creative use and semantic flexibility, as well as containing symbols for constructing grammatically complex sentences.[26]

The graphic symbols, or the letters and written words if the child can spell, may be presented on communication books or boards, or on electronic devices with synthesized speech output.[27] Children with severe motor impairments who rely on graphic symbols to express themselves have access to the lexicon of symbols that others have made available to them. The number of lexical items in the communication aid is much smaller than the spoken language of typically developing peers, and children may have to construct meaning in unusual ways. For example, they need to adjust and adapt their communicative strategies to construct meaning with the available graphic symbols, for instance, by using similar, related or approximate words.[28,29] Spellers do not experience the same limitation, as they may express whatever words they are able to spell. Furthermore, whereas children communicating with graphic symbols depend on the expressive means provided by others, spellers are free to construct varied utterances. Hence, spellers have infinite linguistic possibilities for relaying detailed and specified information, using a conventional and rule-based language system.

Some degree of co-construction of meaning between communication partners is a natural part of all conversations but may be particularly prominent in dyads involving aided communicators, where negotiation of meaning may also be challenging.[30] Young children using natural speech often use holophrases or telegraphic utterances, or shortened or elliptical expressions, that is, single-word or short utterances that express more complex communicative intentions, which older children and adults would have expressed in longer utterances.[31–33] These expressions are also evident in young aided communicators and may persist as a consequence of the limited set of available graphic symbols, like in the example below, which may reflect an early topic-comment structure.

Child: *BREAD*

Adult: *Are you hungry*?

Child: *GREEN*

In this example, the child implicitly made inferences about the state of mind of the communication partner and what she needed to express to make the partner understand the intention. The communication partner incorrectly inferred that the intended meaning of *BREAD* was a request for food and answered by asking the child about her state of mind – hunger. However, the communicative intention of the child was to tell the adult that the bread was moldy, and she therefore added *GREEN* to the construction, a clue that served to guide the adult to understand the intention. Adults may also add extensive semantic and syntactic content to the constructions offered by aided communicators.[34] Although children sometimes may achieve communicative success using holophrases or telegraphic utterances,[35] the co-construction may come with a price: The communication partners may take control of the communication process, using many *yes/no* questions to ascertain the child's intent.[36]

Aided communicators who use spelling may express longer and linguistically more complete utterances and are less dependent upon the partners' inferences and strategies when describing events than children who use graphic symbols.[34] Time and resource usage due to motor impairments may still limit the construction of long utterances. Moreover, children with little or no intelligible speech often have problems learning to read and write, possible due to reduced phonetic knowledge.[37,38] In spite of significant education efforts, their literacy development is often slow compared to their peers and some never achieve the level of mastery needed for everyday communication.[37,39–41]

Regardless of whether the aided communicator uses graphic symbols or letters, conversations with individuals with significantly restricted manual abilities take much longer time than similar conversation using natural speech.[28,42] This may contribute to aided communicators expressing themselves in short utterances. Children using aided communication are more likely to achieve communicative success if, in making their constructions, they are able to consider or synchronize their knowledge with that of the communication partner and the partner's likely assumptions about the context of the utterances of the aided communicator and his communicative intentions. However, limited attention has been given to the development of mind understanding in children using aided communication.[1] There are only a limited number of studies that address this topic, and among these none that investigates how mind understanding affects the communication between an aided communicator and a partner.

Most studies of mind understanding in aided communicators focused on the relationships between performance on false belief tasks, expressive means, comprehension of spoken language and non-verbal reasoning, typically indicating a delay in mind understanding among aided communicators.[1] For example, in a study of 14 children aged five to 15 years who had cerebral palsy and used Blisssymbolics, six participants passed the false-belief tasks, compared to 13 of 14 children with typical development matched for non-verbal mental age. The only difference found between aided communicators who did and did not pass the tasks, was that the latter group was less competent in expressing themselves with Blissymbols.[43] In a longitudinal study assessing children's mind understanding (including false beliefs tasks) first at five to seven and then again at nine to 11 years of age, it was found that the sequence of mastery of the tasks was similar to the typical developmental trajectory but delayed. The authors suggested that the delay reflected less experience with communicative interaction, pointing out that "exposure to spoken language without opportunity for self-initiatives and active managing of the interaction does not seem to be enough for the expected emergence of mentalizing skill" .[44] Another study found that performance of similar tasks was related to comprehension of spoken language and working memory.[45] Evidence of a delay in the development of understanding of others' minds was corroborated in a more recent study.[46] On the other hand, Sundqvist and Rönnberg[47] found that mind understanding in children who were proficient users of Bliss-words was not related to expressive language or comprehension of spoken language, but to nonverbal intelligence and working memory. However, the majority of the participants in this study used speech and manual signs in addition to Blissymbols, and the relationships between expressive and receptive language and mind understanding therefore remain elusive.

The acquisition of aided language can be regarded as a form of language development.[48] However, there is a difference between the developmental trajectories of receptive and expressive language that is not evident in typical language development. There are three main causes for this: (1) there is an asymmetry between the language input (spoken by others) and the output (aided utterances constructed by the child), (2) aided communicators are mainly dependent on the expressive means provided to them by others, and (3) the communication partners usually play a crucial role in inferring meaning from the aided construction, resolving communicative breakdowns, co-constructing meaning and rephrasing the aided constructions in speech.[34,49–51] Communication using aided language forms provides a window into investigating conditions that may influence development in ways that are not possible under typical learning conditions. The present study investigates the performance of children using aided communication or natural speech on a communication task requiring mind understanding – what information the partner needed to be able to infer what objects the child was looking at. Based on the scarcity of relevant research, an exploratory approach was chosen. The study has two research questions:

(1) What are the relationships between the children's age, expressive mode (aided language vs speech), comprehension of spoken language, and non-verbal reasoning and the dyad's performance on the communication tasks?
(2) How does aided language mode (graphic symbols vs spelling) relate to performance on the communication tasks, and what factors might explain any differences between aided communicators using different modes?

Methods

This study was part of the international project *Becoming an Aided Communicator* (BAC) see.[52] The project included a variety of tasks exploring children's understanding of language, and the use of language during communication with a partner (parent, professional and peer) in tasks resembling everyday activities. The project was approved in each participating country according to the national procedures for ethical approval. The children's parents gave written informed consent to the research and to publication of the results.

Participants

Participants were children using aided communication, children using speech and their communication partners, who were parents, professionals and peers of the children.

Professionals from the specialized health care and special education systems recruited the children using aided communication (the aided group) in each of the participating countries. A search was made for aided communicators who met the following criteria: (a) age between 5;0 and 15;11 (years; months), (b) speech production absent or very difficult to understand, (c) had used communication aid(s) for a minimum of one year, (d) hearing and vision within normal range (with and without corrective aids), (e) not considered to have an intellectual impairment by a professional (their teacher or therapist), (f) not received a diagnosis in the autism spectrum, and (f) speech comprehension considered adequate for age. Due to differing organization of services in the participating countries, we were not able to screen for any diagnoses prior to inclusion but relied on proxy report. Information about hearing, vision, and the absence of intellectual disability and autism spectrum disorder, were provided by parents and professionals. We chose to include children of school-age, as in many countries children receive their first communication aid around the time when starting school.[48] The rationale for including children up to 16 years was to be able to include a sufficient number of participants from each country, given that the prevalence of children with severe speech and motor impairment and normal cognition is low.

The naturally speaking children (the reference group) were matched on gender and age, had no known disabilities and either attended the school of the aided communicator or were from the same neighborhood.

Participants were 111 children from 14 countries (Brazil, Canada, Denmark, Finland, Germany, Ireland, Portugal, Norway, Spain, Sweden, Taiwan, the Netherlands, the UK and the US), representing six linguistic groups (Chinese, English, Finnish, Germanic, Latino, and Scandinavian languages). There were 71 children (38/33 girls/boys) in the aided group and 40 children (21/19 girls/boys) in the reference group. Ages ranged from 5;0 to 15;11 years, with a mean age of 11;0 (*SD* 2;11). There were no differences between the aided and the reference group with regard to gender, $\chi^2(1, N = 111) = 0.011$, $p = .918$, or age, $t(109df) = 0.442$, $p = .659$. Within the aided group, children from the six linguistic groups were not significantly different with regard to gender, $F(5, 65) = 0.28$, $p = .923$, or age, $F(5, 65) = 1.87$, $p = .113$.

All aided participants were experienced with using communication aids, having been introduced to a graphic communication aid at an average of 4;0 years and having had access to an aid for an average of 7;2 years (range 2;1 to 14;1 years). There was, however, a large variability in when the first graphic symbol system was introduced, as that ranged from a minimum of 1;0 year to a maximum of 10;0 years. The participants used their regular communication aids during the task (see Table 1 for a description of communication aids used).

Table 1. Characteristics of the 71 children using aided communication.

Variable	Specification	Aided group N (%)
Diagnosis(N = 71)	Cerebral palsy	61 (85.9)
	Other diagnosis	5 (7.0)
	No clear diagnosis	5 (7.0)
GMFCS level(N = 69)	Level 1–2	9 (13.0)
	Level 3	2 (2.9)
	Level 4–5	58 (84.1)
MACS level(N = 69)	Level 1–2	9 (13.0)
	Level 3	11(15.9)
	Level 4–5	49 (71.0)
Viking Speech Scale level (N = 67)	Level 1–2	0
	Level 3	15 (22.4)
	Level 4	52 (77.6)
CFCS level(N = 61)	Level 1	1 (1.6)
	Level 2	31 (50.8)
	Level 3	22 (36.1)
	Level 4	6 (9.8)
	Level 5	1 (1.6)
Spelling ability(N = 46)	Competent speller	16 (34.8)
	Emerging speller	12 (26.1)
	Reluctant speller	4 (8.7)
	Does not spell	14 (30.4)
Communication mode(N = 71)	Orthographic	23 (32.4)
	Combines symbols and orthographic	7 (9.9)
	Symbols	41 (57.7)
Symbol system used(N = 48)	PCS/Pictograms	29 (60.4)
	Blissymbols/Minspeak	19 (39.6)
Communication device (N = 71)	Board	16 (26.7)
	Book	5 (8.3)
	Electronic device	34 (56.7)
	Etran	5 (8.3)
Communication access (N = 71)	Direct	49 (69.0)
	Scanning (high-tech device)	12 (16.9)
	Partner assisted scanning	10 (14.1)
Educational setting(N = 53)	Regular preschool/school	26 (49.1)
	Special group whole or part-time	8 (15.1)
	Special school	18 (34.0)
	Not in school	1 (1.9)

GMFCS = Gross Motor Function Classification System; MACS = Manual Ability Classification System; CFCS = Communication Function Classification System; PCS = Picture Communication Symbol

The communication partners were a parent of the child (for 26% of the tasks), a professional working closely with the child, such as the child's main teacher (for 41% of the tasks), and a peer (for 33% of the tasks). The peers were friends whom the aided communicators knew well, ensuring that they had experience in communicating together. In the few cases where the children in the aided group were unable to suggest a friend, a sibling near in age functioned as the 'peer' communication partner. Children in both the aided and the reference group had communication partners who were parents, teachers, and peers. As data collection for the reference group mostly took place in the schools, the adult communication partner for the reference group were less often parents (16% vs 32%) and more often professionals (48% vs 36%) than in the aided group, due to practical reasons. Both groups interacted equally often with peers (36% vs 32%).

Procedure

Assessments took place in a quiet room, either at the child's school, in the home, or at the institution (university, hospital or similar) where the researcher worked. Typically, the assessments, which included standardized tests and unique project tasks, were delivered over several sessions and days (see below for a description of instruments used).

In the first sessions, which often took place over two to three days and typically lasted one to two hours each day, the child completed standardized tests together with the researcher. Weight was placed upon not having too long assessment sessions each day, taking into consideration that children with severe motor impairments are prone to fatigue.[53]

The task with communication partners was performed on other days than the testing. Typically, the tasks with the professional and peer could be carried out on the same day, while the tasks with the parents was scheduled to take place in the home and on a different day. All tasks completed with communication partners were filmed, using two video cameras where one was capturing the whole dyad and one the child's communication aid. In the reference group, only one video camera was used. In addition to the child and the communication partner, the researcher leading the data collection on the site was present in the room during assessments.

Instruments

Instruments include classification instruments, standardized tests, and the project task *BAC Description without naming*.

Classification Instruments

For the aided communicators, gross and fine motor functioning were classified according to the Gross Motor Classification System (GMFCS)[54] and Manual Ability Classification System (MACS) .[55] Speech was classified according to the Viking Speech Scale[56] and communication with the Communication Functioning Classification System (CFCS)[57] (see Table 1).

Standardized Tests

Language comprehension was assessed with either the Peabody Picture Vocabulary Test (PPVT)[58] or the British Picture Vocabulary Scale (BPVS),[59] depending on the availability of national norms, and with the Test for the Reception of Grammar (TROG) .[60] The PPVT, and its British version BPVS,[61] are both tests of single word vocabulary comprehension, while TROG measures comprehension of sentences and grammar. All three tests have similar formats, requiring the child to indicate the one picture among four that corresponds to a spoken word (BPVS/PPVT) or sentence (TROG). While performance on PPVT/BPVS requires the ability to identify single objects, actions and characteristics, performance on TROG reflects the ability to infer semantic relationships among the elements in an illustration, for example to identify the one picture where a dog is looking at a man from other pictures of dogs and men. Scores on BPVS and TROG correlate around 0.5–0.7 with each other and with other measures of language comprehension.[62,63] Non-verbal reasoning was assessed with Raven's Matrices[64,65] or with matrices from the Kaufman Brief Intelligence Test (KBIT),[66] depending on national guidelines for the use of Raven. Both tests require the child to identify the one answer option among six to eight alternatives that would logically fit into and complete a pattern. Both tests correlate around 0.7–0.9 with other measures of intelligence.[67,68] All results are reported as z-scores (i.e., zero is the age-average score and the standard deviation (*SD*) is one).

All the tests were selected because they place limited demands on motor skills, as the child is required to indicate one of a fixed number of answer alternatives. For children unable to point using their finger, eye-gaze pointing or partner-assisted scanning (i.e., that answer options are pointed out in a systematic manner and the child accepts or rejects each alternative in turn) were used. Altering response mode in this manner does not influence test results.[63]

Table 2. Scoring categories on the BAC description without naming task.

Type of clues		Example of clues for "apple"
Precise	Clues that make it easy to infer, such as providing superordinate category, a similar example or function	*A fruit. Like a banana. You can eat it.*
Imprecise	Clues that are correct, but nonspecific, such as color of the object or the letter the word starts with	*It is red. It starts with an a.*
Incorrect	Clues that are incorrect or misleading	*Something blue.*
Spontaneous	Clues provided by child before partner makes first guess	
Elicited	Clues provided by child after partner has made first guess	

The Project Task

The task *BAC Description without naming* was used to assess mind understanding. The task involved the child describing a drawing of a common object (e.g., an apple) without naming it, to a communication partner who could not see the drawing. The partner was asked to infer what kind of object it was from the child's description. The child was allowed to add to the description for as long as he or she deemed necessary. To help the partner correctly name the object, the child thus had to recognize when the communication partner lacked information and consider what information would best enable the partner to infer what was depicted. The task thus required the child to make inferences about the communication partner's thinking.

The BAC Description without naming task consists of three training items (one for each partner) and nine task items (three for each partner) (see also previous publications where the task has been used.[69–71]) The order of partners was varied between the children, so that all items in the task were solved with all three communication partners, that is, one child would solve the first three of nine items with a parent, the next three with a professional and the last three with a peer, while another child would solve the first three items with a professional, the next three with a peer and the last three with a parent.

Information provided by the child (termed 'clues') on the nine task items was categorized as superordinate (e.g., 'animal' for describing the picture of a horse), similar (e.g., donkey), functional (e.g., ride on), attribute (e.g., brown), ownership (e.g., uncle has one), phonological (e.g., starts with *h*), idiosyncratic (e.g., therapy), associated (e.g., saddle) or incorrect (e.g., ice-cream) .[71] The clues were then grouped according to their transparency as (a) precise (superordinate, similar and functional clues), (b) imprecise, but correct (attribute, ownership, phonological, idiosyncratic and associated clues), or (c) incorrect. The partner's answer was scored as either correct (i.e., answering horse) or incorrect (i.e., answering cow instead of horse). If the answer was incorrect, the child had the opportunity to add additional clues. The child's clues were also categorized as either spontaneous (provided before the partner made a first answer) and elicited (provided after the partner's first answer) (see Table 2). The following is an extract showing how a child (C), aged 10;9 years at time of assessment and using aided communication, in the form of graphic symbols (Blissymbolics), communicated with her teacher (T) on the task with the drawing of a (brown) horse:

C: *ANIMAL*

T: An animal

C: *BROWN*

T: A brown animal? A brown animal.

C: *BIG*

T: [Asks the researcher a question about the rule of the task]

T: Then I think it is a horse.

C: 'Yes' (smiling and nodding)

In the excerpt above, the child gave three clues, of which one was categorized as superordinate ('animal') and two as attributes ('brown' and 'big'). All three clues were classified as spontaneous, as they were provided before the partner made her first guess. (What the teacher says before guessing horse is not scored, as it was just a repetition of what the child had said). The task was scored as correctly solved and we noted that the dyad took altogether 200 seconds to complete the task. The child also confirmed the answer was correct.

The items did not have to be completed within a set time limit. An item ended when the child expressed satisfaction with the communication partner's response, and the time of the interaction up to that point was recorded.

The principal researcher in each country videotaped, transcribed and when necessary, translated the conversation between the child and the partner into English, and classified the clues and guesses, according to written specified guidelines. All information provided by the child on the nine items was coded, including the information that the child gave before and after the communication partner made the first guess. The English transcriptions and the categorization of the clues were reviewed at meetings between the researchers to ensure consistency across sites. Reliability was investigated using the tasks of four children and computing an intra-class correlation (ICC), yielding an intra-rater reliability ICC of 0.94, $p < .001$.

Statistical Analysis

The scores on the tests of verbal comprehension were normally distributed (as per Shapiro-Wilk's test of normality, $p > .05$), and independent samples t-tests were used to compare cognitive functioning in the aided group and the reference group. Number of clues was not normally distributed (Shapiro-Wilk's test of normality, $p < .05$) and there were more participants in the aided group, so non-parametric tests were chosen for analyses of performance on the BAC Description without naming task. The Mann-Whitney U test was used to compare the distribution of type of clues between the groups, and the Spearman's rank-order correlation to explore associations between cognition and performance on the task. All analyses were performed using IBM SPSS Statistics 25.

Results

To answer the first research question, we explored differences between the aided dyads and reference dyads and related these to the relationships between age, verbal comprehension, non-verbal reasoning and task performance.

The children in the aided group provided significantly fewer clues per item, solved fewer items and required more time than the reference group (see Table 3). The percentage of precise clues and the average number of elicited clues did not differ significantly between the two groups.

When the two groups, aided and reference, were analyzed together, percentage of solved items on the BAC task was significantly related to age, $r = .24$, $p = .011$, verbal comprehension (BPVS/PPVT, $r = .21$, $p = .009$ and TROG, $r = .33$, $p = .022$) and nonverbal reasoning (Raven/KBIT, $r = .34$, $p = .009$) and (see Figure 1).

To investigate the impact of expressive mode, the relationships in the two groups were studied separately. In the aided group (see Table 4), percentage of solved items on the BAC task was related to age, $r = .37$, $p = .001$ and sentence comprehension measured by the TROG, $r = .34$, $p = .040$, while the correlations with vocabulary comprehension BPVS/PPVT, $r = .16$, ns., and Raven/KBIT, $r = .23$, ns., did not reach significance. The relationship between percentage of solved items and age in the aided group was not explained by scores on verbal comprehension or non-verbal reasoning, as it remained significant when controlling for verbal comprehension (mean of BPVS/PPVT and TROG), $r = .39$, $p = .006$ and non-verbal reasoning (Raven/KBIT), $r = .45$, $p = .001$. In the reference group, neither age, verbal comprehension, or non-verbal reasoning were significantly related to percentage of solved items.

The average test scores in both the aided group and the reference group were within two *SD*s of the age mean: BPVS/PPVT $M(SD) = -1.2(1.3)$ vs 0.3(1.2), TROG $M(SD) = -1.3(1.4)$ vs −0.6(0.9) and Raven/KBIT $M(SD) = -1.4(1.4)$ vs 0.7(0.8). Compared to children in the reference group, the children in the aided group scored significantly lower on BPVS/PPVT, $t(67) = -3.921$, $p < .001$ and Raven/KBIT, $t(55) = -3.967$, $p < .001$, but not on the TROG, $t(46) = -1.579$, $p = .121$.

The second research question pertained to differences related to mode of aided communication. In the aided group, there was no difference between the graphic symbol users and the spellers in the average number of clues provided or time required, but the dyads with spellers solved significantly more items and used a larger percentage of precise clues than the children using graphic symbols (see Table 5). Aided communicators using graphic symbols scored significantly lower than the spellers on the tests of verbal comprehension (BPVS/PPVT, $M(SD) = -1.4(1.3)$ vs −0.6 (1.2), $t(51) = -2.162$, $p = .035$ and TROG, $M(SD) = -1.8(1.2)$ vs −0.4 (1.1), $t(36) = -3.758$, $p = .001$), but not on the tests of nonverbal reasoning (Raven/KBIT, $M(SD) = -1.7(1.3)$ vs −0.9(1.5), $t(48) = -1.891$, $p = .065$). There was no difference with regard to age ($M(SD)$ = 10;9(3;1) vs 11;11 (2;7), $t(69) = -1.546$, p.127).

We further analyzed if factors other than aided language mode (symbol use vs spelling) might explain the differences. Within the aided group, linguistic background (spoken language in the country of residence) was not related to scores on the verbal tests, $F(4, 46) = 2.062$, $p = .101$, percentage of solved items, $F(5,65) = 2.233$, ns., or preciseness of clues used, $F(5, 62) = 1.225$, ns. Nor was there any relationship between percentage of correct items and how long the aided communicator had used a communication aid, r = . 22, ns., or access method used (direct selection vs scanning), $t(69) = -1.04$, ns. Furthermore, we found no differences in percentage of solved items that could be related the communication partner (parent, professional, peer) (see Table 6).

Discussion

This study explored the performance of a large sample of aided communicators with cognitive functioning in the typical range on a communication task involving mind understanding. Their mean test scores being within two standard deviations of the age average supported the professionals' perception of the aided communicators as having intelligence within the typical range.

Table 3. Percentage of solved items, time used and type of clues per item in the aided and reference group.

	Aided group(N = 71)			Reference group(N = 40)					
	M	*SD*	*M rank*	*M*	*SD*	*M rank*	*U*	*z*	*p*
Task performance									
Percentage of solved items	63.6	32.6	44.8	93.4	13.1	76.0	2 218	5.115	<.001**
Time used (sec)	193.1	181.1	39.8	50.0	95.0	13.9	80	−4.987	<.001**
Average type of clues per items done									
All types	2.5	1.5	46.7	3.3	1.6	65.7	1 757	3.065	.002**
Precise	0.9	0.5	45.4	1.3	0.7	67.9	1 840	3.618	<.001**
Imprecise	1.3	0.9	46.7	2.0	1.2	65.7	1 755	3.052	.002**
Incorrect	0.3	0.6	60.8	0.0	0.1	40.4	794	−4.045	<.001**
Spontaneous	1.8	1.2	44.4	2.7	1.3	69.7	1 908	4.061	<.001**
Elicited	0.7	0.7	56.0	0.6	0.7	49.1	1 124	−1.111	.267
Percentage of type of clues provided									
Precise	40.2	16.5	52.3	42.6	15.7	55.6	1 373	0.531	.596
Spontaneous	76.8	18.3	48.6	84.3	16.5	62.2	1 623	2.187	.029*

U = Independent samples Mann-Whitney U test.
**p* < .05 ***p* < .01

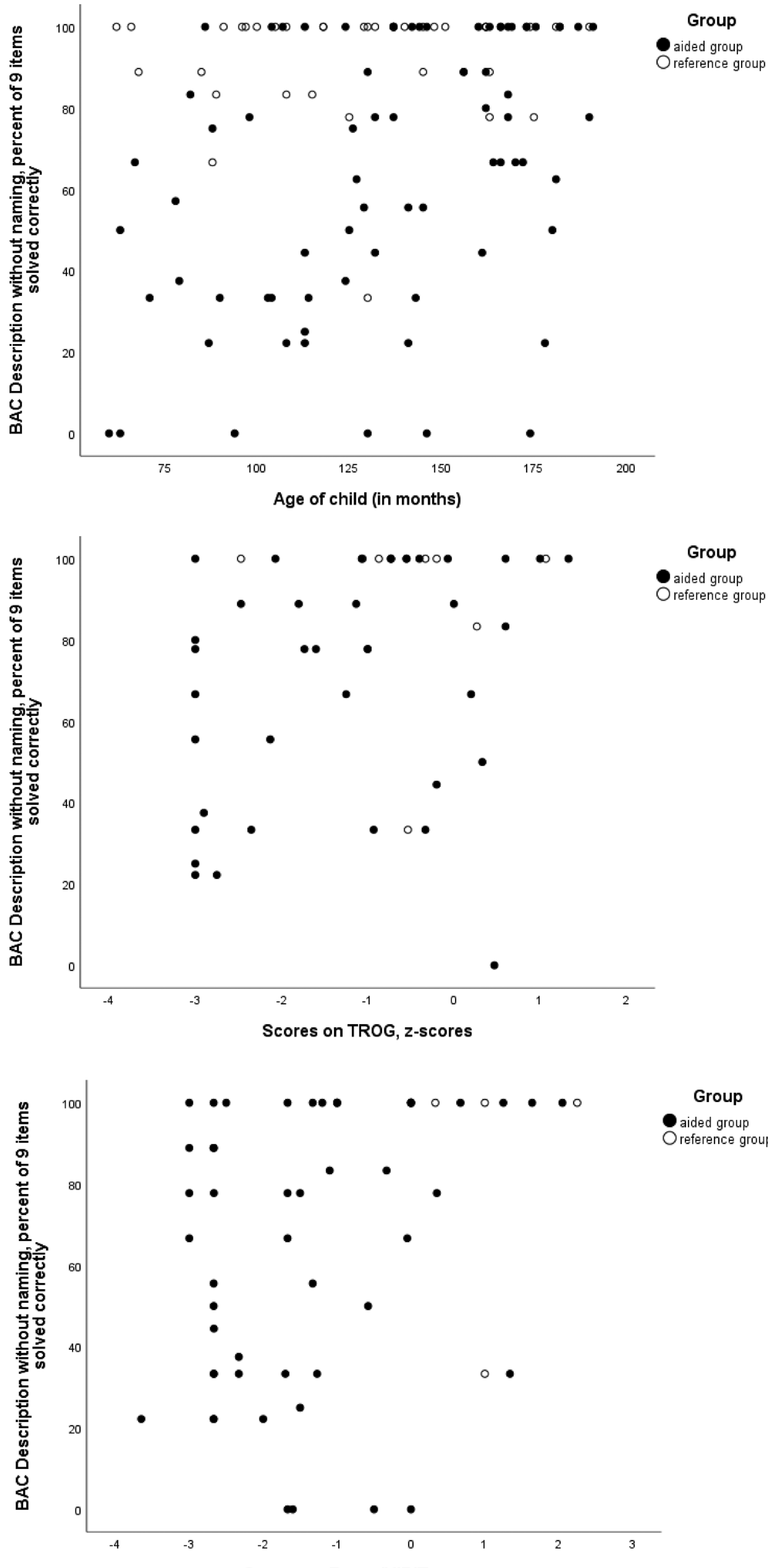

Figure 1. The relationships in the aided and reference groups between percentage of correctly solved tasks on BAC description without naming and age, sentence comprehension (scores on TROG) and non-verbal reasoning (scores on Raven/KBIT) .

Table 4. Relationships between age, language comprehension and performance on the BAC description without naming task in the aided group: spearman rank correlation coefficients (number of participants).

	1	2	3	4	5	6	7
(1) Age		−.29* (53)	.25 (38)	−.26 (50)	.37** (71)	−.04 (68)	.14 (68)
(2) BPVS/PPVT			.63** (32)	.43** (43)	.16 (53)	−.04 (50)	.20 (50)
(3) TROG				.43** (36)	.34* (38)	.13 (37)	.32 (37)
(4) Raven/KBIT					.23 (50)	.01 (48)	.16 (48)
(5) Percentage of solved items						−.08 (68)	.17 (68)
(6) Percentage of spontaneous clues							.10 (68)
(7) Percentage of precise clues							

BPVS = British Picture Vocabulary Scale; PPVT = Peabody Picture Vocabulary Test; TROG = Test for Reception of Grammar; Raven = Raven's Colored or Standard Matrices; KBIT = Matrices from the Kaufman Brief Intelligence Test
*$p < .05$, **$p < .01$

The first research questions concerned whether the participants' performance on the communication task was related to age, expressive language mode, comprehension of spoken language or non-verbal reasoning. Results indicated that age of the child and percentage of correct answers correlated positively in the aided group, but not in the reference group. The relationship stayed significant even when controlling for level of verbal comprehension and non-verbal reasoning in the aided group. As almost all of the reference group's answers were correct, the results suggest that the *BAC Description without naming* tasks can be successfully completed by five-year-olds with typical development. This shows that the linguistic skills involved in the task were moderate and that other aspects of the task performance were more important to explain the results. At five years of age, children with typical development are expected to have developed aspects of mind understanding, including the understanding that people's beliefs depend on the relevant information they may have.[9] The relationship between age and task performance in the aided group therefore suggests that the development of mind understanding is delayed in children using aided communication, an interpretation which is consistent with earlier reported the findings[44,46] and which highlights the role that expressive opportunities plays in the development of mind understanding.[1]

In the current study, the children had to provide sufficient relevant information, without naming the object, for the partner to infer what the child was describing. The dyads in both groups solved the majority of the items correctly, but the success rate was lower in the aided group than in the reference group (64% vs 93%) and there was more variation within the aided group (where correct scores ranged 0–100%, compared to the reference group where it ranged 33–100%). The difference between the aided group and the reference group indicates that the available expressive means may influence task performance. The aided communicators had more limited expressive means than the reference group of naturally speaking children as communication aids have a relatively limited lexicon and a small number of grammatical items for constructing sentences.[52] Compared to children with typical development who have large vocabularies and a grammar to form their utterances, they may have to rely on a time-consuming construction of aided utterances.[26,28,42,49,50] It is possible that the communicative means of young aided communicators lead to less experience with communicative interactions beyond daily routines and everyday activities.[30,72] This would imply less experience with conversations involving greater demands on mind understanding, which might contribute negatively to their performance on tasks requiring such understanding.[10,16]

Overall, the aided communicators were able to provide clues related to the objects in a manner that enabled the communication partner to make correct inferences for 64% of the items. The correct percentage varied between items (range 55–75%), but this could not be related to type of depicted object as two edibles (bread and apple) were the ones with the lowest and the highest score, respectively. Aided communicators have in previous studies been found to have experience with vocabulary pertaining to food, and communication about daily life activities and basic needs are situations that the aided communicators are likely to have experience with.[27,30,73] Therefore, our finding suggests that availability of vocabulary in the communication aids is probably not the most decisive factor in determining success on the communication task, but rather providing the information that is needed for the partner to understand.

It may be noted that the percentages of precise clues were similar in the two groups (40% vs 43%). Thus, although the aided communicators provided less information, possibly due to the extra time and effort that had to be invested in message construction, they were as precise as their speaking peers. This supports previous findings that aided communicators are just as able to stay on topic as their peers when describing scenes and events unknown to a communication partner.[74] Both groups provided most of the information before the partner made the first inference, indicating that their information was relevant and held on to their original idea about what kind of information their partner needed to infer the nature of the object depicted.

The results of our study indicate that task performance was also related to language comprehension, particularly to comprehension of sentences. In the aided group, performance on the communication tasks and scores on a test of sentence comprehension (TROG) were positively related. The aided group and the reference group did not score significantly different on TROG, but as the reference group successfully completed almost all of the communication tasks, a similar relationship between task performance and TROG was not found in this group. The results of the aided group are consistent with usage-based theories of language development[75,76] and extend findings of prior studies[77,78] by relating comprehension of grammar and sentence structure to communication tasks involving mind understanding.

When examining both the aided and reference group together, there was a positive relationship between non-verbal reasoning (measured by scores on the tests Raven or KBIT) and percentage of solved items on the communication tasks. This relationship was not evident when analyzing the groups in separation. In the aided group, the relatively large proportion of scores in the lower range on Raven/KBIT may explain why the positive relationship did not reach statistical

Table 5. Percentage of solved items, time used and type of clues per item in aided communicators who are symbol users and spellers.

	Symbol users (N = 48)			Spellers (N = 23)					
	M	*SD*	*M rank*	*M*	*SD*	*M rank*	*U*	*z*	*p*
Task performance									
Percentage of solved items	55.2	32.1	30.5	81.3	26.4	47.5	815	3.278	.001**
Time used (sec)	192.5	197.6	23.2	194.1	154.5	24.0	255	0.193	.847
Average type of clues per items done									
All types	2.6	1.8	34.3	2.3	0.9	34.9	515	0.111	.911
Precise	0.9	0.6	31.0	1.0	0.3	41.8	668	2.122	.034*
Imprecise	1.3	0.9	34.7	1.2	0.7	34.2	499	−0.098	.922
Incorrect	0.4	0.8	37.7	0.1	0.2	27.9	361	−2.102	.036*
Spontaneous	1.9	1.4	32.8	1.8	0.7	38.1	584	1.024	.306
Elicited	0.7	0.7	36.2	0.5	0.7	30.9	426	−1.052	.293
Percentage of type of clues provided									
Precise	37.7	17.3	31.1	45.5	13.8	41.5	661	2.027	.043*
Spontaneous	75.0	18.5	32.4	80.5	17.5	38.8	602	1.255	.210

U = Independent samples Mann-Whitney U test.
*$p < .05$ **$p < .01$

significance. In the reference group, a non-significant correlation may be explained by a ceiling effect with limited variation in scores on the communication tasks.

Our second research question was related to differences in the aided language modes used by participants, specifically, graphic symbols and letters. The partners in the dyads with spellers correctly inferred a higher percentage of items than in the dyads using graphic symbols (81% vs 55%). The children who used spelling conveyed more precise information and gave less incorrect information than the children using graphic symbols. This difference could be due to a larger vocabulary and more grammatical resources available for children who use spelling, implying more varied linguistic experiences, which enable greater linguistic flexibility and specificity to present the information needed.[4]

Task success was not dependent upon familiarity between the aided communicator and the communication partner. However, it might be that it is not the partner per se, but the type of aided communication used, which plays a role. Graphic communication systems and letters make different demands on the conversational partners. Users of graphic symbols are likely to be more experienced with co-construction than aided spellers, as the symbol users typically use shorter utterances and thus are more reliant on the communication partner than children who are spelling for getting their full intended meaning across.[34] Although this implies that their communication partners were used to making inferences about what the child wanted to convey, our findings show that their inferences were not always correct. It is not evident why the spellers would perform better than the graphic symbol users on tasks involving well-known objects and quite simple vocabulary. The significant time taken to produce an aided utterance might have been a possible distinguishing factor,[27] but the time usage was similar in the two aided groups. Neither did age, non-verbal reasoning, the length of time using a communication device, access method used to operate the communication device or linguistic background differ between the two aided groups. However, the graphic symbol users scored lower on the tests of verbal comprehension than the spellers. This finding strengthens the assumption that mind understanding may be related to verbal comprehension.[45]

It has been argued that investigations of mind understanding in children using aided communication add to the clinical field by yielding a better understanding of how to best support the children's communication.[79] The finding that the aided communicators who were spellers performed better than their peers who used graphic symbols speaks to the importance of prioritizing literacy instruction in programs for children using aided communication. It is still not clear how best to support the development of reading and writing in children with severe speech and motor impairments.[37,41] Because the development of literacy skills is uncertain even for aided communicators with age-appropriate intellectual skills, in parallel with providing them with the best possible reading and writing instruction,[80–82] they may benefit from an augmentative and alternative approach to support or substitute alphabetic writing. This should include early introduction of an advanced graphic symbol system that allows for the construction of grammatically complex utterances with graphic symbols and combinations of graphic symbols and letters, such as the Blissymbolics system or Widgit Literacy Symbols.[83] Guidance to more varied communicative experiences with constructing phrases and especially with conveying unknown information to communication partners might support the development of both aided communication and mind understanding. Furthermore, the current study also suggests a need for more detailed assessment of the comprehension of spoken words and sentences among young aided communicators.

Limitations

The outcomes of this study should be interpreted with respect to its limitations.

Data were collected in 14 different countries and while this multi-cultural and multi-linguistic approach is a strength, it also implied some challenges related to translation and incomplete data sets (overall 82% of the items were completed by the aided communicators, see Table 6). However, as a comparison of aided communicators from different linguistic backgrounds

Table 6. Number and percentage of the nine items of the BAC description without naming task done and solved by the aided group (n = 71) and number of items done and percentage of solved items per communication partner (parent, professional and peer).

	Items done	Solved of items done	Parent	Professional	Peer	
			Number of items donePercentage of solved itemsMean (SD)			
	N(%)	N(%)				Statistics
Item 1 *Book*	60 (85)	42 (70)	N = 2171 (46)	N = 956 (53)	N = 967 (50)	$F(2, 36) = 0.34, p = .717$
Item 2 *Boat*	60 (85)	37 (62)	N = 2176 (44)	N = 944 (53)	N = 967 (50)	$F(2, 36) = 1.42, p = .254$
Item 3 *Bread*	57 (80)	32 (56)	N = 1872 (46)	N = 1040 (52)	N = 875 (46)	$F(2, 33) = 1.75, p = .190$
Item 4 *Apple*	64 (90)	48 (75)	N = 1080 (42)	N = 2576 (44)	N = 967 (50)	$F(2, 41) = 0.23, p = .799$
Item 5 *Chair*	60 (85)	38 (63)	N = 875 (46)	N = 2157 (51)	N = 1070 (48)	$F(2, 36) = 0.48, p = .625$
Item 6 *Balloon*	59 (83)	35 (59)	N = 1050 (53)	N = 2370 (47)	N = 850 (54)	$F(2, 38) = 0.78, p = .464$
Item 7 *Ladder*	53 (75)	32(60)	N = 838 (52)	N = 1173 (47)	N = 1968 (48)	$F(2, 35) = 1.46, p = .246$
Item 8 *Bicycle*	57 (80)	41 (72)	N = 862 (52)	N = 1080 (42)	N = 2070 (47)	$F(2, 35) = 0.32, p = .728$
Item 9 *Mirror*	57 (80)	35 (61)	N = 838 (52)	N = 1080 (42)	N = 2055 (51)	$F(2, 35) = 1.74, p = .190$
SUM	527 (82)	340 (64)	112	128	112	

yielded no significant results, variability among aided communicators is more probably related to other factors than the linguistic background.

The children in the aided group used their own communication devices when solving the task. While this ensures ecological validity as the children's performance may resemble more closely how they solve similar communicative challenges in everyday settings, it also implies that the children would have access to different vocabulary. To minimize the effect of this, common objects were chosen for the children to describe (see Table 6).

It was an inclusion criterion that the children's cognitive functioning should be in the typical range, and this was confirmed by tests. However, the aided group scored significantly lower on tests of vocabulary comprehension and non-verbal reasoning. This may reflect that specific factors, such as vocabulary knowledge being influenced by adult selections and expressive opportunities.[84] Therefore, the relationships between specific cognitive impairments and the development of mind understanding should be explored in further studies.

The present study is not longitudinal and hence it is not possible to ascertain whether (a) the child's level of verbal comprehension influenced the choice of aided communication system, if (b) fewer or different expressive experiences impacted sentence comprehension and mind understanding, or if (c) it was the choice of aided communication mode which had unintended negative long-term consequences for linguistic and cognitive development. However, even though causal inferences cannot be established, the results of our study underline that there are many important reasons for providing children who have little or no speech with rich and varied experiences with expressive communication.

Conclusion

The results of the current study, as evidenced both by the difference in performance between the aided and the reference group and between aided communicators using symbols and spelling as expressive mode, suggest that limited experience with producing complex expressive language may negatively affect performance on tasks requiring mind understanding. Using a communicative mode that depends on co-construction of meaning, aided communicators using graphic symbols may not have acquired the mind understanding and strategies that enable them to make themselves fully understood by their communication partners. Furthermore, verbal comprehension, and in particular comprehension of sentences and grammatical structures, may be related to how well a child performs on communicative tasks requiring mind understanding.

The results did not reflect a general delay in intellectual development in the aided group but rather that the development of mind understanding may be related to expressive means and experiences, verbal comprehension and age. Age may to some extend be viewed as an expression of communicative experience. Together, these findings emphasize the need to provide young aided communicators with robust communication systems that enable them to construct complex utterances and engage in truly reciprocal conversations involving the exchange of unknown information as early as possible.

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