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Lexical and grammatical development in a child with cochlear implant and attention deficit: A case study

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Abstract

This is the first study to explore lexical and grammatical development in a deaf child diagnosed with Attention Deficit Hyperactivity Disorder, Inattentive sub-type (ADHD/I). The child, whose family language was Spanish, was fitted with a cochlear implant (CI) when she was 18 months old. ADHD/I, for which she was prescribed medication, was diagnosed 3;6 years later. Speech samples were videotaped over the first 4 years of CI use and during a follow-up session 1 year later. Samples were transcribed according to CHAT conventions and several measures of expressive language were obtained. Receptive language was evaluated with standardized tests. Results show that while some aspects of her development seemed relatively positive (e.g., acquisition of verbal morphemes at the same auditory age as typical children), other characteristics were atypical for a CI user: (1) preference for paralexical expressions in early lexicon; (2) lexical errors in colours and other abstract words; and (3) low MLU and varied grammatical errors including disorganized discourse. Medication had a positive effect on all these characteristics, providing evidence of a link with ADHD/I. This study concludes that ADHD/I had a direct impact on the lexical and grammatical development in this child, as well as an indirect influence over her communicative style. More studies are needed to explore language characteristics of children with CI and ADHD.

Keywords: *grammatical acquisition, lexical acquisition, cochlear implant, ADHD*

Introduction

Today there is clear evidence that early cochlear implantation makes it possible for prelingually deaf children to acquire oral language (Nicholas and Geers, 2008). However, there is some variation in the reported benefits offered by cochlear implants (CI). While some children seem to catch up quickly with typically developing (TD) same-age peers, other children may not benefit as much from CI use (Pisoni and Cleary, 2003).

One cause of slow post-CI development is the presence of an associated impairment. According to Edwards (2007), over 30% of deaf children have an associated impairment, which attests to the need to investigate these cases. The few studies that have reported on such

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children show that CIs are beneficial for most children (see Edwards, 2007, for a review). However, current studies provide very few details about these cases, and most of these studies involved children who were implanted relatively late (i.e., 4 or more years of age).

As regards children with CI and Attention-Deficit/Hyperactivity Disorder (ADHD), two studies have included children with ADHD as part of group studies in children with complex needs. Vlahovic and Sindija (2004) examined one child with ADHD and moderate psychomotor delay; however, the authors did not provide information specific to this child. Waltzman, Scalchunes, and Cohen (2000) included two children with ADHD. Both children, who received their CI at the ages of 3;11 and 7;6, respectively, showed noteworthy progression in their perceptual skills after 1–2 years of CI use. Pundir, Nagarkar, and Panda (2007) described two more children with ADHD implanted at the ages of 6 and 7 years, respectively. They found that, 3 months post-activation, both children had very limited listening skills. The children were tested again after 6 months of medical treatment, and both children showed significant progression in perception and in production. It is important to note that these studies refer to children implanted after 3 years of age. We do not know of any study that has explored younger children with CI+ADHD.

In order to explore the impact of ADHD on CI users, it seems reasonable to compare scores of these children with scores of CI users without associated impairments. However, due to the known variability in CI users (Pisoni and Cleary, 2003), other selection criteria should be considered as well. For this case study, we will consider three variables that have been shown to explain part of the variability in CI users: age of implantation (Nicholas and Geers, 2008), user-specific communication mode (Le Normand, 2008), and family involvement (Spencer, 2004). As described in the method section, this child was implanted early (18 months), her family used Cued Speech, and they were highly involved in rehabilitation.

Lexical and grammatical development in CI users

In children implanted before 30 months of age, benefits of CI are observable during the first year of implant use, both quantitatively and qualitatively (Nott, Cowan, Brown, and Wiggelsworth, 2009a, 2009b). Quantitative reports have shown that many deaf children acquire a large number of words in the first year of CI use. For instance, the child described by Ertmer and Mellon (2001) produced nearly 100 different words in 12 months of CI use (as measured by the *MacArthur Communicative Development Inventories*, Fenson, Dale, Resnick, and Bates, 1993). Other studies have found even larger increases. However, in a recent study, Nott et al. (2009a) suggested that there are differences between CI users and hearing peers. They explored time to acquire first 50 and first 100 words in a group of children implanted under 30 months of age and in a control group of hearing children. Both groups demonstrated acceleration in lexical acquisition from the first 50 words to the next 50 words. However, acceleration was significantly higher in the hearing group.

As for quality of early lexicon, Nott et al. (2009b) explored lexical categories (Nelson, 1973; see Appendix) in early CI users and in hearing controls. Both groups showed similar distributions of word categories, with nominals constituting the largest portion, and grammaticals the smallest portion of the lexicon. However, in both the 50- and 100-word lexicons, the hearing group used proportionately fewer predicates, more common nouns, and fewer onomatopoeic words in comparison with the control group. Further, more participants in the hearing group used grammatical word types other than adverbs (including pronouns) compared to the hearing loss group. The authors conclude that, despite the benefits of early implantation, hearing loss continues to impact early lexical acquisition.

After 3 or 4 years of CI use, language levels—as measured by quantitative evaluation tests—are close to the mean for TD children (Kirk, Miyamoto, Lento, Ying, O'Neill, and Fears, 2002; Svirsky, Teoh, and Neuburger, 2004; Nicholas and Geers, 2008). Nicholas and Geers (2008) explored spoken language skills in 78 pre-school children with CI who had been implanted between 12–36 months. A linear relation emerged between test scores and age at implantation for all scales administered: auditory comprehension and expressive language (*Preschool Language Scale-3*; Zimmerman, Steiner, and Pond, 1992), and receptive lexicon (*Peabody Picture Vocabulary Test-III*, Dunn and Dunn, 1997). For children implanted between 12–14 months of age, expected scores were at the mean for their TD same age peers. For children implanted at the age of 18 months, expected scores were between 10–20% below the mean. Geers, Moog, Biedenstein, Brenner, and Hayes (2009) obtained similar results.

A potential limitation of these quantitative studies is that they may not detect specific deficits (Le Normand, 2004; Geers, 2005). For instance, Szagun (2004) analysed speech samples of a group of German-speaking children with CI who were implanted between the ages of 1;2 and 3;10. The language of the most advanced children was compared with that of a group of TD children with a similar Mean Length of Utterance (MLU). Results showed that general linguistic progress, as measured by an increase in MLU over a time period of 28 months, did not differ between the two groups. However, children with CI made more frequent article omissions than TD peers, and the number of errors in article form selection increased with MLU.

A similar contrast between relatively fast progression in MLU and occasional—but atypical—grammatical errors has also been observed by Le Normand (2008) in a long-term longitudinal study of French-speaking children. As French and Spanish are both Romance languages, this study is particularly relevant for us. The authors compared the MLU in three sub-groups of CI children without associated disorders in order to explore the benefits of communication systems: Cued Speech (CS), Cued Speech + Sign Language (CS+SL), and Sign language (SL). At every data point, the ordering of the three groups (in terms of MLU) followed this pattern: CS >> CS+SL >> SL. For the CS group, scores after 18 months, 3 years, and 5 years of CI use were, respectively, 1.8, 3.3, and 4.8. For the CS+SL group scores were 20–30% lower in each session. For the SL group, the contrast was even higher. The MLU of the youngest CI users in the CS group (age at implantation < 24 months) was the highest in the group. After 18 months of CI use, the MLUs of these two children were 2.9 and 2.58. After 3 years, their MLUs were 5.0 and 6.58, which are comparable to hearing peers. However, close examination of the language produced by these two children showed the presence of some grammatical errors (agreement errors with determiners, preposition substitution, and pronoun omission) that are not observed in typical children (Le Normand, 2008).

Another variable that influences development in CI users is family involvement (Spencer, 2004). Family involvement is important mostly because highly implicated parents tend to create the most favourable conditions for language development and to compensate potential deficits (see Moreno-Torres and Torres, 2010).

In sum, research has confirmed that language development in early CI users is similar to that of normally hearing children, and that CI users tend to catch up with their TD peers. Nevertheless, there are qualitative differences both in first words and in grammar, even in early implanted children.

ADHD: Impact on language development

ADHD is characterized by three primary symptoms: poorly sustained attention, impulsiveness, and hyperactivity. It occurs in ~ 3–7% of the childhood population (Barkley, 1990) and 7% of

deaf children and young people (Gallaudet Research Institute, 2008). The *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV) of the American Psychiatric Association (1994) distinguished three sub-types of Attention-Deficit/Hyperactivity Disorder: inattentive (ADHD/I), hyperactive–impulsive (ADHD/H), and combined sub-type (ADHD/C), which comprises the symptoms of the other two sub-types. Children with ADHD/I are described by parents and educators as hypoactive, passive, etc. On the contrary, children with ADHD/H are seen as hyperactive and even aggressive.

As heredity is believed to be the most common cause of ADHD (Waldman and Gizer, 2006), the deficit may be present from birth. However, ADHD is typically detected after the age of 6 years, when it has a negative impact on educational achievements (Lahey, Pelham, Stein, Loney, Trapani, and Nugent, 1998). According to Barkley (1997), poor behavioural inhibition is the central deficiency in ADHD, but this deficiency impacts negatively four executive functions that depend on such inhibition for their own effective performance: working memory, internalization of speech, self-regulation of affect–motivation–arousal, and reconstitution (i.e., the decomposition of sequences of events or messages into their parts). Pharmacological treatment has been demonstrated to be effective for ADHD (Elia, Borchending, Rapoport, and Keysor, 1991). It increases attentional resources, producing a positive impact on both social and communicative skills (Ygual, 2003).

As ADHD is typically detected when language has already been acquired, little is known about the specificities of language development in this group of children. However, there is evidence that speech delay is relatively common in this population (Gupta and Ahmed, 2003; Tannock and Schachar, 1996). For example, Gupta and Ahmed (2003) conducted a retrospective analysis of a group of 74 children with ADHD and 75 controls. In their study, speech delay had been present in 48.6% of the ADHD group (12% in control group). Speech delay was the most common early clinical marker for later development of ADHD.

Expressive and receptive language skills have been studied in children with ADHD who are 5 or more years of age (Baker and Cantwell, 1992; Cohen, Vallance, Barwick, Im, Menna, Horodezky, et al., 2000; Ygual, 2003). Results are not conclusive. Some authors (e.g., Ygual, 2003) have found significant differences between TD and ADHD children both in expressive and receptive language; however, other studies have not found differences between the two groups. For instance, Redmond (2004) compared three groups of children (ADHD, SLI, and TD). Several variables (number of different words, MLU, and composite tense) differentiated the SLI group, but the other two groups were similar (SLI < ADHD = TD). However, the author mentions that variability within the ADHD group was important. Linguistic errors of children with ADHD are more evident in discourse (Zentall, 1988; Ygual, 2003) and also in pragmatically inadequate responses to adult questions (Purvis and Tannock, 1997). These results are compatible with the fact that ADHD has more to do with a deficit in executive functions than with language impairment (Barkley, 1997; Doyle, 2006).

Goals of the present study

The aim of this study is to explore language development in a child with CI+ADHD. In a previous study, Moreno-Torres and Torres (2008) explored the second year of CI use in this child. Note that at that point in time, the authors did not know that the child had ADHD/I. In this paper, the first, third, and fourth years of CI use will be analysed. Specifically, we want to answer the following questions:

(1) Which were the main features of this child's lexical and grammatical development as compared with other CI users?
(2) Did ADHD have a negative impact on her lexical and grammatical development?

In order to answer these questions, we will explore early lexical development (first year of CI use) as well as later lexical and grammatical development. Several measures of early development will be compared to the same measures of two CI users with similar demographic characteristics but without associated impairment. As for later lexical and grammatical development, because there are no data from other Spanish-speaking children with CI, results will be compared to Spanish-speaking TD children and to children with CI who speak languages other than Spanish.

Method

Main participant

The main participant in this study, B, is the same child described in Moreno-Torres and Torres (2008). Profound bilateral deafness was detected when the child was 13 months of age. When the girl was 14.5 months old, she started an intensive family-centred rehabilitation programme (Torres, Ruiz-Casas, Moreno-Torres, and Santana, 2008). Central to the programme was the use of Cued Speech (Cornett, 1967). When she was 17 months old, B was fitted with a unilateral CI, which was programmed 1 month later. A parental questionnaire of perception was administered (*LittlEars Auditory Questionnaire*, Kühn-Inacker, Weichbold, Tsiakpini, Coninx, and D'Haese, 2003). The pre-CI score was 1 (maximum: 35); post-CI scores after 1, 3, 6, and 12 months of CI use were, respectively, 16, 28, 29, and 34. According to the implantation centre, such scores are at the mean for children with CI. The Spanish version of *Test of Non-verbal Intelligence-2* (Brown, Sherbenou, and Johnsen, 1995) was administered, and B's non-verbal IQ score was 118 (percentile 87).

When she was ~ 4 years old (i.e., after 2;6 years of CI use), B began to show several signs of atypical development: (1) Despite evident improvement in intelligibility (which was comparable to that of her same-age peers), B seemed to have frequent comprehension problems (e.g., with *wh-* questions). (2) She seemed to have short-term memory limitations. For instance, if asked to fetch something from another classroom, B would go to that room, but once there she would not remember what she had to bring back. (3) In general, B had difficulties learning the rules of new activities, and she very much disliked being tested; however, she developed strategies to compensate for her limitations. For instance, with the *Syllable Board*, which has three columns of cards, each column with five ordered syllables (i.e. column 1: ba, be, bi, bo, bu; column 2: pa, pe, pi, po, pu, and so on), the child is required to locate the syllable that the adult produces. This is a straightforward task for 5-year-old children who can read the individual syllables, as B could. After some weeks practising this task, the therapist observed that B did not locate the syllables directly. Instead, she had memorized the full list of syllables (ba, be, bi, bo, bu, pa, pe, . . .), as if it were a song. In order to locate a syllable, B would sing the list of syllables while she ran through the full list.

Based on these and similar signs, the speech therapist suggested that the parents take B to a specialist paediatrician. When B was 5 years old, after 3;6 years of CI use, she was diagnosed with ADHD/I (inattentive). The diagnosis was based on the presence of all the symptoms of inattention described in DSM-IV (American Psychiatric Association, 1994). These symptoms were apparent for more than 6 months—both in language therapy sessions and at home—to a degree that was disruptive and judged inappropriate for a child with CI. B did not show

symptoms of hyperactivity or impulsivity. Sluggish cognitive tempo (Todd, Rasmussen, Wood, Levy, and Hay, 2004) was not present either. She immediately began treatment with Methylphenidate (5 mg/day in the first month, and 18 mg/day in the next months).

Comparison participants

B's early lexical development was compared to that of two other CI users (CM, a male, and CF, a female). These children are part of a study in progress (Moreno-Torres, Torres, Santana, and Cid, 2009) and were selected for comparison because of matching with B on pre-implant perception, age of implantation (15 and 20 months) and family involvement (high). Family involvement was scored independently by each child's therapist and one member of the research team. Both judges were asked to take into account a wide variety of aspects (participation in therapy sessions, knowledge of deafness, daily stimulation to the child, etc.) and to provide a unique score for each family (min: 1; max: 5). Mean results were 4.5 for B, and 4.0 for CM and CF. Four other children were considered for comparison, but were excluded from this study due to other factors (one was pre-term, another had an associated impairment, and two other children scored 2.0 on the family involvement scale).

Materials

The core results of this research are based on a set of 150 speech samples from B and two adults (alternatively her mother and her therapist). Each sample corresponds to a 30-minute session. All the samples were videotaped on a Sony semi-professional mega pixel 3CCD digital video camera recorder DCR-TRV950E Pal. A sampling rate of 48 kHz was used for the recordings.

In order to explore early lexical development, we selected a sub-set of the corpus that was parallel to that of comparison participants CM and CF. A total of 11 samples was used: one pre-implantation sample, eight samples collected at 1.5-month intervals for 1 year, and two final samples after 15 and 18 months of CI use. For the third and fourth year (before the initiation of treatment for ADHD), 41 samples were used. Finally, 12 samples were selected to explore the benefits of treatment.

The samples were transcribed according to CHAT conventions (MacWhinney, 2000). Coders were the second and third authors. The first author revised all the transcriptions, adopting the most conservative decision in case of disagreement with previous coder (e.g., the error was annotated only if both coders agreed that there was an error). As data corresponding to the second year of CI use have been analysed by Moreno-Torres and Torres (2008), the results and discussion sections include only the most relevant information about that period. In order to obtain additional data that might help to interpret results from the first 4 years of observation, the child was further evaluated after 5 years of CI use, and a new speech sample was videotaped and transcribed.

Procedure

Early lexicon. Word identification in the first year of CI use was based on phonetic form consistency and the relationship of that form with an adult word. The Clan programme (MacWhinney, 2000) was used to obtain the first 50 and 100 word types. Following Nott et al. (2009b), words were classified as *nominals*, *grammaticals*, *paralexicals*, and *predicates*. See Appendix for details within each category. A lexical error was defined as the use of a word for

the wrong referent (e.g., use of 'dog' pointing to a 'cat'). It is probable that some lexical errors passed undetected, as videos do not always provide sufficient contextual information.

Coding: Morphology. Using the Clan programme, word types were obtained for different age ranges. A morpheme (e.g., simple past, indicative, second person singular) was included in the list of morphemes produced by the child if it appeared at least three times, with two different lexemes (used spontaneously). Regularizations of irregular verb forms were annotated manually as morphological errors. Agreement errors, either in noun phrases or in verb phrases, were classified as syntactic errors.

Coding: Syntax. The following production error types were annotated: *noun phrase agreement* errors, *subject-verb agreement* errors, *other substitution errors* (e.g., wrong preposition, clitic, etc.), and *omission* of grammatical words. When it was difficult to identify errors (generally because there were several of them in the same utterance) the utterance was marked as having a single error named *general*. In order to detect potential comprehension errors, we analysed B's answers to adult's questions. We selected only questions (1) that were syntactically simple (e.g., 'who is this?'; 'what is she doing?') and (2) for which the child had sufficient information to give a reasonable answer. For instance, an easy question might occur if in front of a family photo the mother asks: 'Who is this?' A difficult question might occur if the adult suddenly changed the topic of the conversation. Adult questions were extracted from 48 sessions in the third and fourth year of CI use. Answers were annotated as potential errors if the child did not reply, or if the reply was not pragmatically relevant.

Formal tests

Receptive lexicon was evaluated with the Spanish version of the *PPVT-III* (Dunn, Dunn, and Arribas, 2006). Grammar comprehension was evaluated with the *CEG* test (Mendoza, Carballo, Muñoz, and Fresneda, 2005), which is the Spanish adaptation of the *Test for Reception of Grammar* (Bishop, 1983).

Reliability

Agreement between two investigators was required both for lexical and grammatical data. In the first year, candidate words were credited as words only if independent listener transcriptions agreed. Thus, data for word identification represent 100% agreement between transcribers that a minimum level was achieved. The same conservative criteria were used to classify words in any of the lexical categories described in Appendix, as well as for lexical and grammatical errors. In order to determine agreement between coders, 10% of the corpus was recoded. Cohen's Kappa between coders was 0.83 for word identification in the first year, 0.86 for expressive lexical errors, 0.87 for expressive grammatical errors, and 0.83 for comprehension errors.

Results

Early words

Time to produce first 50 words and 50–100 words in the three children was: 9.0 and 4.5 months (B); 7.5 and 3.0 months (CM), and 6.0 and 3.0 (CF). Thus, in the three children there was a marked reduction between the first and second period. As Figure 1 shows,

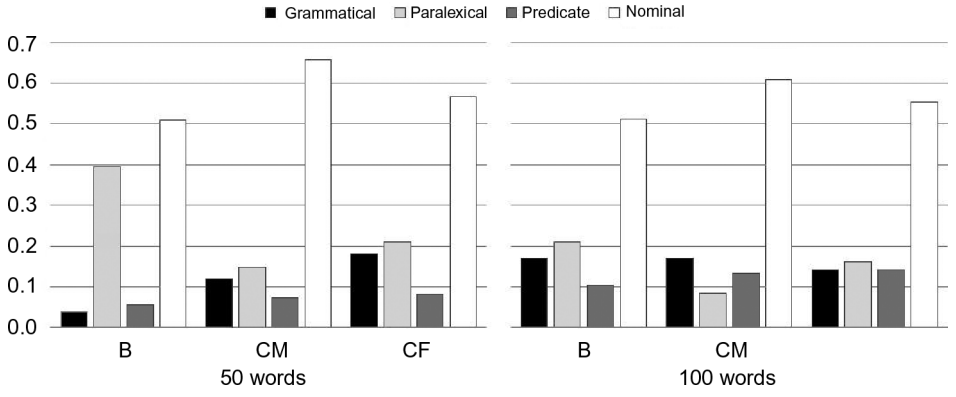

Figure 1. Percentage of word types in the 50- and 100-word lexicon in B and the two comparison children.*

* Percentages correspond to the first session in which the accumulated number of types was higher than 50 or 100 respectively. For B, word types were 53 and 123. For CM: 67 and 128. For CF: 60 and 99.

nominals were the most important category during the 50-word stage for the three children. However, there are differences in paralexical and grammatical words. For B, paralexicals represent a higher percentage (40%) than for the comparison children (15% and 21%, respectively). Examination of the paralexical category showed that B produced a large number of interjections (10 types) and frozen forms (seven types). As for grammatical words, results were: 4% (B), 12% (CM), and 19% (CF).

Second, third, and fourth year of CI use

Expressive lexicon. During the second year of CI use, an impressive progression was observed in B's expressive lexicon (see details in Moreno-Torres and Torres, 2008). This growth continued over the next 2 years. By the end of the second year of CI use, the mean number of word tokens produced spontaneously per session was 292. In the third year, the mean was 496. In the fourth year the mean was 650 before medical treatment, and 542 thereafter. Despite such obvious progression in productivity, lexical errors persisted, mainly with *colours*, *verbs*, and *adjectives* (see Table I). Error types changed over time. Initially, most frequent errors were colours; later on, errors in adjectives and verbs were more frequent. When B began treatment for ADHD, the number of errors increased (see Figure 2).

Receptive lexicon. B was evaluated at the auditory ages of 2;3 and 4;0 using the *PPVT* test. At the age of 2;3, her standard score was 104, which corresponds to a chronological age range of 2;11–3;3 years (see Moreno-Torres and Torres, 2008). At auditory age 4;0, her standard score was 93, which corresponds to an age equivalent of 3;8. Thus, her performance on the *PPVT* was consistently in the average range when adjusted for auditory age.

Expressive grammar. Corpus data showed that B acquired the Spanish article system in the second year of CI use (see Moreno-Torres and Torres, 2008). Verbal morphemes were observed productively between the second and third year of CI use, with the same auditory

Table I. Lexical errors.

AE	Spanish utterance	English equivalent
2;9	la caja es para no *caliente* (adj.)	the box is not *to hot*
	Correct: la caja es para no *quemarse* (verb)	Correct: the box is not *to get burnt*
3;0	*se va* un zapato	a shoe *goes*
	Correct: *viene* un zapato	Correct: a shoe *comes*
3;1	para *cantar*	*to sing*
	Correct: para *oír* música	Correct: *to listen* to music
3,1	*Pequeño*	*small*
	Correct: *grande*	Correct: *big*
3;2	yo no *busco* el cuchillo	I am not *looking for* the knife
	Correct: yo no *encuentro* el cuchillo	Correct: I can't *find* the knife

AE: Auditory age.

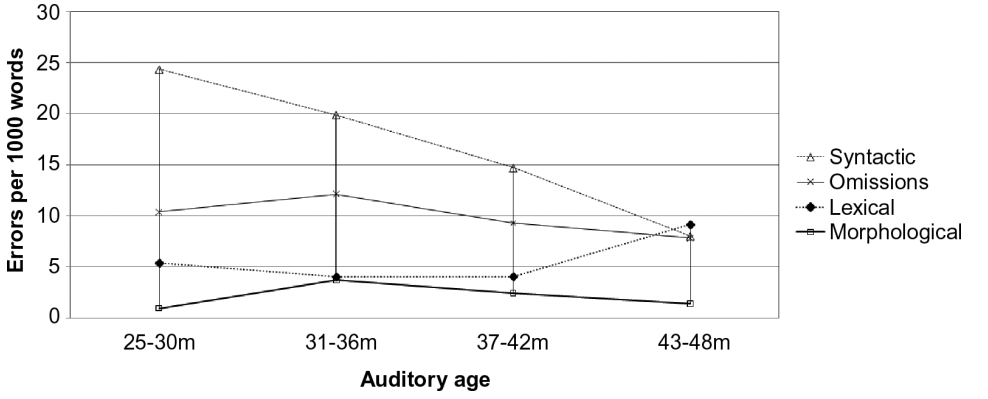

Figure 2. Linguistic errors per 1000 words.

age as TD children (see Table II). Moreover, B produced 11 regularization errors (e.g., *cierrado* for *cerrado*, English: 'closed'; *rompido* for *roto*, English: 'broken').

Corpus data showed that B's MLU increased very slowly in this period. Her MLU was 2.2 during the third year of CI use and 2.5 during the fourth year (before treatment). Her MLU did not vary significantly during the treatment (MLU = 2.6). Occasional syntactic errors were observed throughout this period (see Figure 2). During the second year of CI use, noun phrase agreement errors were the most common (see details in Moreno-Torres and Torres, 2008). In the third year of CI use, those agreement errors decreased, but new error types appeared: subject–verb agreement, omissions, etc. An important set of errors in B were those classified as *general* (see Table III). One illustrative example is '**me han pegado con el pelo*' (literally: '*someone hit me with the hair'). Possibly the child meant to say '*me han pegado con algo en la cabeza*' (English: 'someone hit me with something on my head'). Such example suggests that she had difficulties organizing complex utterances.

Receptive grammar. At the auditory age of 4;0 (chronological age of 5;6), her score on the *CEG* test of receptive grammar was 39 (scores for 4;0 year old children are: $M = 48.5$, SD = 9.2). Thus, her score on the test was low even for her auditory age. Corpus data showed that B often had difficulties answering relatively simple questions. In the 34 sessions that preceded

Table II. Verb forms produced after 18, 24, and 30 months of CI use compared with TD children* of the same auditory age.

Tense\Aud.Age	18 months	24 months	30 months
Simple present	2, 3, sing	1 sing, 1,3 plur	
Present perfect	3 sing		1,2 sing
Simple past			3 sing (−)
Imperfect past			3 sing
Future			(−)
Subjunctive		2 sing	3 sing (−)
Imperative	2 sing		
Infinitive	-ar, -er, -ir		
Gerund		-ando, -endo	
Verb periphrasis		ir+inf/estar+ger (+)	

* TD data from Serra, Serrat, Solé, Bel, and Aparici, (2000). A minus sign (-) indicates the morpheme appears later in B. A plus sign (+) indicates the morpheme appears earlier in B.

Table III. Grammatical errors (general).

AE	Spanish utterance	English equivalent	Comments
3;1	y el niño está *saltando* a *jugar* los niños	And the boy is *jumping* to *play* the kids	Maybe the child swapped two verbs, trying to say 'is playing to jump with the kids'
	Correct: unknown		
3;4	¿y qué pasa *en* la niña ?	And what happens *in* the girl	Clitic has been omitted and preposition is wrong.
	Correct: ¿y qué *le* pasa *a* la niña?	Correct: and what clit_pronoun happens *to* the girl?	
3;4	Pues ha hecho *pintando*	So she has made *painting* (gerund)	Probably she omits several words.
	Correct: unknown		
3;4	*porque quiere muy divertidos los puzles*	Because she wants very funny the puzzles	Maybe she collapses two sentences ('puzzles are funny' + 'she wants puzzles') into one.
	Correct: unknown		
3;5	que se va ir reloj	That it's going to leave watch	Nonsense discourse
	Correct: unknown		

AE: Auditory age.

medical treatment, 1655 questions were annotated (M = 48.6 per session). Only 22% of her answers were judged to be pragmatically appropriate. In general, the child either did not answer or provided pragmatically inadequate answers. In the 14 sessions that coincide with the treatment, 863 questions were annotated (M = 68.7 per session). During this period, 77% of the replies were cooperative. The improvement was evident both to parents and to professionals, and suggested that most of her difficulties might be related with ADHD.

Follow-up

After 5 years of CI use, B's standard score on the *PPVT* was 81, which corresponds to a chronological age range of 4;11. On the *CEG* test of receptive grammar, her score was 58 (which

is the mean for 5-year-old children). Thus, B scored at the mean for children of her auditory age on both tests. Her MLU, calculated from a 30-minute speech sample, was 4.2 (number of utterances = 178). Qualitative exploration showed that the majority of her utterances were grammatically correct, but some subject–verb agreement errors and omissions appeared in relatively complex and long utterances. Note that these errors are similar to the ones observed among typical CI users, which suggests that the medication was having a positive impact on language.

Discussion

The main aims of this study were to explore longitudinally lexical and grammatical development in a child with CI+ADHD/I, and to examine whether or not ADHD/I had negatively impacted her language development. In order to address these goals, we will organize the discussion in the following sections. First, we will summarize the most relevant linguistic characteristics of her development. Second, we will analyse whether such characteristics are typical for a CI user. Third, we will explore the direct impact of ADHD/I on lexical and grammatical development. Finally, we will examine some indirect consequences of ADHD/I on the communicative style of this child, which partly explain the difficulty in interpreting results.

B's lexical and grammatical development

Quantitatively, B's early lexical development was very similar to that of the two comparison children (with CI, but no associated impairment). Qualitatively, differences were found at the 50-word, but not at the 100-word, stage. At the 50-word stage, B produced dramatically more paralexical and less grammatical words than the comparison children. B included a large number of interjections and frozen forms in the paralexical group. Note that except for grammatical words, which were more frequent among the Spanish-speaking comparison group, results of CM and CF closely resemble results in the Nott et al. (2009b) study; the observed difference in that category may be related to cross-linguistic differences between Spanish and English.

As for lexical development in the third and fourth years, the more relevant feature was the persistence of lexical errors, especially in more abstract words (colours, adjectives, verbs). Receptive lexicon scores were in the average range when adjusted for auditory age. As regards expressive grammar, corpus data suggested that B was acquiring morphosyntax at the same speed as TD children. Also presence of over-regularizations suggested that she was not treating complex expressions as if they were frozen forms. However, B made varied grammatical errors, and MLU progression was notably slow. As for receptive grammar, the delay with respect to TD children had increased after 4 years of CI use.

During the 18 months of treatment for ADHD, some changes were observed. Lexical errors increased initially, but they seemed to disappear after 18 months of treatment. Grammatical errors tended to disappear with treatment. Finally, other unusual features (difficulty with *wh*-questions, disorganized discourse, and low MLU) disappeared also with medication.

Was lexical and grammatical development atypical for a CI user?

The well known variability—not only in CI users but also in typical children (Bates, Bretherton, and Snyder, 1988)—as well as the lack of reliable references for Spanish-speaking CI users makes it difficult, or even impossible, to give a clear answer to this question. However, we may observe that there are specific features of this child with CI+ADHD/I that are uncommon among other CI users. The following features of B's language may be unusual for a CI user: (1)

strong preference for paralexical expressions in early lexicon; (2) lexical errors with abstract words; and (3) varied grammatical errors and low MLU scores.

Paralexical expressions were very frequent in her 50-word lexicon. This preference may be related to a holistic information processing style (Bates et al., 1988) and thus be an individual form of variation (which may also explain relatively frequent grammatical errors). However, other features of her expressive language suggest that her style was not holistic: preference for nouns in the 100-word stage and in later development (see Moreno-Torres and Torres, 2008), and over-generalization errors in morphology. Thus, we conclude that the high frequency of paralexicals in early lexicon is atypical for a CI user.

Three facts suggest that B's lexical errors are atypical: (1) such errors were not observed in the two comparison children in this study; (2) other researchers have emphasized difficulties with grammar in CI users (Le Normand, 2004; Szagun, 2004), but lexical errors have not been documented; (3) errors in colours have been observed in atypical populations (Pennington, 2006), but not in CI users. However, the fact that errors are relatively infrequent shows that the difference between B and other CI users is qualitative rather than quantitative.

Similarly, B's expressive grammar was qualitatively different from that of other CI users: (1) B's errors are more varied (i.e., errors affected a wide set of structures) and often with several errors in the same sentence; (2) some of her errors suggested a difficulty organizing and planning sentences (which may explain some general errors) or a pragmatic deficit (such as her replies to *wh-* questions) that has not been documented in CI users. Another aspect of her development, low MLU, also seemed atypical. However, as B was acquiring verbal morphemes at the same auditory age as TD children, we must find an explanation for this other than a grammatical impairment. We will return to this below. To conclude, we observed these atypical aspects of lexical and grammatical development: preference for frozen forms in early lexicon, qualitatively important lexical errors, and varied grammatical errors.

Did ADHD have an impact on language development?

We must be cautious in the interpretation of the specific nature of the deficits in B's language development. As noted in the introduction, results about the impact of impaired executive functioning on language development are not conclusive. However, it seems reasonable to explore if a link exists in this case. Specifically, we consider that a link may exist between B's language deficits and impairment of two executive functions (Barkley, 1997): internalization of language and reconstitution. A difficulty in internalizing language may explain B's preference for context-dependent expressions, such as the ones she produced during the 50-word stage (interjections and frozen forms). The fact that at the 100-word stage her lexicon was similar to that of typical CI users shows that she started very slowly to use language skills in the service of executive control, which is necessary to verbally encode and rehearse lexical knowledge. In other words, B's entrance into language was slow, which is characteristic of children with ADHD (Gupta and Ahmed, 2003). Later errors with colours and other abstract words might also be related to ADHD. Note also that errors in perception of colours have been documented in these children (see Banaschewski, Ruppert, Tannock, Albrecht, Becker, Uebel, et al., 2006). A difficulty in reconstitution (analysis/synthesis) may explain atypical grammatical errors (general errors and inadequate replies to *wh-* questions). Note that such errors were observed in relatively complex sentences for which analysis/synthesis skills are especially important: to identify parts in an event (analysis) and to construct the complex utterance (synthesis) that describes such event. This difficulty in organizing complex sentences has been documented in other children with ADHD (Purvis and Tannock, 1997; Ygual, 2003; Zentall, 1988).

The impact of ADHD/I was also confirmed by the changes observed while B was taking medication. The features that were atypical for CI users (low MLU, lexical errors, disorganized sentences) were not observed after 18 months of medication. The only errors that remained (agreement, omissions) were similar to those that have been observed in other CI users. Thus, we conclude that ADHD had a major impact on the lexicon and grammar of this child.

Indirect consequences of ADHD

Results of this study suggest that, apart from the direct impact on lexicon and grammar, ADHD may have also had a negative impact on B's communicative style. Importantly, this communicative style was associated with several confounding factors that made it difficult to identify language errors. One of these confounding factors was low MLU. Contrary to what is commonly observed, B's low MLU (i.e., 2.6 after 4 years of CI use) was not clearly associated with poor morphosyntactic development. Similar results have been observed in other language-impaired children (Johnston, Miller, Curtiss, and Tallal, 1993). Like the children in the Johnston et al. study, B tended to answer questions with inadequately short utterances. Johnston et al. propose that this occurs in children who are aware of their language impairments, as B was. Thus, low MLU was most possibly related with a communicative style that was aimed at hiding language impairment. Another confounding factor of ADHD was a preference for memorizing patterns, which was probably a compensatory mechanism to avoid errors (similar to the one used to solve analytic tasks, see method section). Together, low MLU and a preference for fixed patterns may be related with this contrast in B's case: her expressive language was appropriate for her auditory age and errors were occasional (see Figure 2); however, such errors were qualitatively very important. A possible explanation is that low MLU and a preference for fixed patterns had the effect of reducing the number of errors. Finally, these confounding factors may explain the initial increase in lexical errors with medication. Possibly, improvement in executive functioning made the child use language more freely, thus making errors visible. We do not know why the change was not immediately observable in utterance length. In sum, ADHD did not only have a direct impact on language; it also pushed the child towards a communicative style that made the language impairment less obvious. More studies are needed to explore whether these indirect consequences of ADHD are common to other children with ADHD.

Conclusion

This is the first study to explore language development in a child with CI+ADHD/I. It illustrates the complexities of identifying and interpreting language errors in these children. Complexity arises not only from the combination of underlying impairments (perception, cognition, and executive functioning); it also arises from the confounding factors that such impairments introduce. Furthermore, lack of reference data makes it difficult to discriminate atypical errors from typical ones for a CI user. Thus, this study shows the need to investigate qualitatively the development of both typical and atypical CI users, so as to have a better understanding of the impact of different impairments on language development.

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Appendix: Word categories and sub-categories*

Noun	Elements used to designate entities
Proper	Names of people, places, etc. For example, own name, pet name, mum, dad.
Common	Animate and inanimate (includes toilet words).
Onomatopoeia	Word that resembles the sound associated with an object or action or seems naturally suggestive of its qualities. *brmm*, *ticktock*, *pom*, *shh*
Predicates	Elements used to tell something about entities.
Verbs	Designate actions and states. Copulative and auxiliaries are not included in this category
Adjectives	Qualities attributed to entities including colour words.
Grammaticals	Function words
Adjectives	Locative, temporal and manner adverbs: *aquí* ('here'), *allí* ('there'), *fuera* ('outside'), *así* ('in this way'), etc.
Determiners	Articles and other determiners (possessives, demonstratives, etc.)
Pronouns	Personal, demonstrative, relative, and possessive pronouns, including clitic pronouns
Prepositions	Prepositions, including forms *al* ('to+the') and *del* ('of+the')
Conjunctions	Particles used to coordinate/subordinate such as *y* ('and'), *que* ('that').
Question words	Particles such as *qué* ('what'), *quién* ('who'), etc.
Auxiliaries	Copulative (*ser* and *estar*) and auxiliary verbs (*haber*).
Paralexical	Unconventional words, supralexicals such as formulae and words of social value.
Interjections	Expression of emotion. It includes both traditional interjections (*ah*, *oh*, *uy*) as well as insult words used without lexical content (e.g., *tonto*, 'silly').
Social	Greetings and other forms of interaction: *hola* ('hello'), *gracias* ('thanks'), etc.
Frozen phrases	Combination of two of more words none of which have been used previously by the child. Frozen forms also include expressions that the child uses as part of a song or play (i.e., as part of a ritual), such as *Cumpleaños feliz* ('happy birthday').

* Adapted from Nott et al. (2009b).