Language Development and Mild-to-Moderate Hearing Loss: Does Language Normalize With Age?

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Purpose: The authors' purpose was to explore the nature of the link between hearing loss (HL) and language impairment in adolescents with mild-to-moderate hearing loss (MMHL). Does language performance (generally or in certain areas) normalize at adolescence?

Method: The language skills of 19 French-speaking adolescents (ages 11–15) with moderate or mild sensorineural HL were evaluated via a series of tests assessing oral and written language, including an experimental probe, and compared with typically developing adolescents and adolescents with specific language impairment (SLI).

Results: Language disorders were found, notably in the areas of phonology and grammar, in more than half the adolescents with MMHL; affected domains and error patterns were identical to those found in adolescents with SLI. Language scores of the adolescents with MMHL were significantly linked with degree of HL, a correlation not generally found in studies of children with MMHL.

Conclusion: Normalization of language performance does not generalize at adolescence in the context of MMHL. The fact that an effect of the severity of HL was found only after childhood might be because linguistic development is basically complete at adolescence. Prior to this time, this effect could be obscured by developmental rhythms that vary from child to child.

KEY WORDS: mild-to-moderate hearing loss, language, normalization, adolescence

Mild-to-moderate hearing loss (MMHL) corresponds to an average hearing loss (HL) in the range of 21 to 70 decibels. Many children with MMHL have HL across the whole range of speech frequencies, whereas others may hear nearly normally at low frequencies but have a marked impairment for high frequencies. Congenital sensorineural MMHL affects many children. Although no real prevalence figures seem to be available, it is clear that MMHL is much more frequent than more severe HL. For example, Mehl and Thompson (1998) reported on a newborn hearing screening in Colorado, in which, of 41,796 infants screened, only 7 children among the 75 infants with bilateral sensorineural HL had profound hearing loss, the remaining having milder HL.

Language development with MMHL has both typical and atypical components. Children with MMHL usually attend regular schools, though in some cases with extra support. Most use hearing aids, but they do not generally acquire sign language (unless they have family members with more severe HL) or use visually coded systems (such as cued speech), although they do rely on lip reading. Moreover, these children do have some spontaneous oral language development. However, sensorineural HL entails not only lowered hearing thresholds, but also distortion of sounds

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(Robier, 2001), and this means that language input is partial and degraded. Although language input can be ameliorated through hearing aids, HL in this population is very often detected at relatively advanced ages: Averages range between the ages of 4 and 5 according to most studies (Hansson, Forsberg, Löfqvist, Mäki-Torkko, & Sahlén, 2004; Stelmachowicz, Pittman, Hoover, & Lewis, 2004; Tuller & Jakubowicz, 2004). This means that the bulk of the crucial years for language development takes place with language input that is partial and distorted. Indeed, given the strong psycholinguistic and neurolinguistic evidence for the existence of a critical period for language acquisition (generally shown to span the first 6 or 7 years of life; see Bailey, Bruer, Symons, and Lichtman, 2001, for an overview), one would expect that many children with MMHL are at risk for delayed language development. It is also interesting to note that epidemiological studies (see, e.g., Wattier-Launey & Ployet, 2001) have shown a correlation between unilateral HL and poor performance at school. If this is the case for children with unilateral deafness, it seems reasonable to expect these difficulties in children who suffer from HL, albeit mild or moderate, in both ears. Growing up with MMHL, and especially with a long period of undetected HL, also has predictable consequences on psychological and social development (see, e.g., Davis, Elfenbein, Schum, & Bentler, 1986; Rondal & Seron, 1999), such as higher rates of aggressiveness, somatization, immaturity, or interactional problems.

Studies of language development that focus on individuals with MMHL are relatively rare. In these studies, significant proportions of children with MMHL have been found to have impaired language (vocabulary, phonology, and morphosyntax performance being below age level), though the groups of children studied show considerable linguistic heterogeneity that has generally, and unexpectedly, not been correlated with degree of HL. We review this literature here.

Davis et al. (1986) administered an extensive evaluation (as measured by Peabody Picture Vocabulary Test—Revised [PPVT–R], Dunn & Dunn, 1997; Wechsler Intelligence Scale for Children—Revised, Wechsler, 1974; reading comprehension tasks; etc.) to 40 children and adolescents ages 5–18 who were divided into three groups: 16 participants whose pure-tone average (PTA) was 15–44 dB, 15 participants whose PTA was 45–60 dB, and 9 participants whose PTA was 61–75 dB. Results showed wide variation, with HL of any degree being associated with low performance on measures of academic achievement, language (in particular, vocabulary development), and personality. Davis et al. concluded that even minimal HL places children at risk for language and learning problems. Results on personality tests showed that the children with HL scored significantly higher than the norm on scales of aggression and somatization. Children were described by their parents as having more problems interacting with others and establishing friendships than is normal and as having much greater than average difficulty in school (another manifestation of difficulty in school was raised by Bentolila, 1996, who reported that the illiteracy rate of individuals with moderate HL is two or three times greater than normal). Finally, no significant difference was found between language performance (or academic achievement) and HL subgroups (and age groups), leading the authors to conclude that "it is not possible to predict hearing-impaired children's language or educational performance on the basis of degree of HL alone" (p. 60). The same result was found by Blamey et al. (2001) in a study including measures of speech perception and language (PPVT; Clinical Evaluation of Language Fundamentals—Third Edition [CELF–3; Semel, Wiig, & Secord, 1995]; and conversational language samples) in a population of 87 children with moderate (n = 15), severe, or profound HL. The aim of this study was to describe the relations between speech perception and production, language, HL, and age. Not surprisingly, a link was found between degree of HL and perception scores. More surprisingly, given the variability of HL in the group studied, no correlation between degree of HL and language scores was found.

Three studies have looked at novel word learning in children with MMHL: Gilbertson and Kamhi (1995), Stelmachowicz et al. (2004), and Hansson et al. (2004). In Gilbertson and Kamhi's study, the population consisted of 20 children with MMHL ranging in age from 7;9 (years; months) to 10;7 with a mean of PTA of 46.1 dB. The authors found that 10 of these 20 children exhibited significantly poorer performance on most of the measures of phonological processing and novel word learning (they required more trials to learn a novel word) than the other 10 children with HL and the normal-hearing children. They suggested that this result might indicate that the children with MMHL could be categorized into two groups: a group of typically developing children who happened to have HL and a group of children with language impairment who have a HL. This hypothesis was pursued in a subsequent study by Wolgemuth, Kamhi, and Lee (1998), which focused exclusively on children and adolescents with MMHL (N = 13, ages 10;0–15;7, mean PTA = 50.2 dB) who performed within normal age limits on selected norm-referenced measures of language. Performance on metaphor comprehension and use was shown to be entirely comparable to that of children with normal hearing and typical development. Interestingly, and consistent with the results of Davis et al. (1986), both the Gilbertson and Kamhi study and the Wolgemuth et al. study concluded that degree of HL is generally not related to measures of language performance.

Novel word learning was assessed in a study by Stelmachowicz et al. (2004) of 11 children with MMHL ages 6–9 (mean PTA = 55.1 dB), compared with 20 children of the same age with normal hearing. Overall performance on the novel word-learning task (based on identification of novel words heard in a story) was 60% for the normal-hearing children and only 41% for the children with MMHL. Significant predictors of performance for all children were the level of lexical development (as measured by PPVT), volume of stimuli (50 vs. 60 dB), hearing status (hearing impaired vs. normal hearing), and number of repetitions, but not degree of HL. Stelmachowicz et al. noted that the proportion of children with language impairment in their study was below that found by Gilbertson and Kamhi (1995; though the exact percentage is not provided). Moreover, their study revealed that although receptive vocabulary performance (on PPVT) was indeed weaker in the children with MMHL, this difference decreased with age.

Hansson et al. (2004) studied novel word learning (using Gilbertson & Kamhi's, 1995, method) in relation to working memory in children with MMHL (ages 9;1–13;3; HL from 30 dB to 57.25 dB) and in children with a preschool diagnosis of SLI. In addition, a range of language tests was used to assess receptive vocabulary (PPVT–R), language comprehension (Test for Reception of Grammar; Bishop, 1983), phonological short-term memory (nonword repetition), and reading. Children with MMHL were significantly better than children with SLI on tasks assessing novel word learning, sentence comprehension, and reading accuracy. When the population was divided into two groups according to HL (13 children with mild HL, <50 dB in best ear; 5 children with moderate HL, >50 dB in best ear), no significant difference between them was found on any language measures.

A difference was found, however, by Briscoe, Bishop, and Norbury (2001) in a study of phonological processing, language, and literacy in 19 children with MMHL compared with children with SLI. Children with MMHL were aged from 5;9 to 10;7 and had HL varying from 20 to 70 dB, though most children had only mild HL: 3 children had moderate HL (PTA of 41 dB–70 dB), 13 children had mild HL (PTA of 20 dB–40 dB), and 3 children had a PTA of less 20 dB but with hearing thresholds greater than 25 dB at two or more frequencies above 2000 Hz (high-frequency HL). Briscoe et al. found that 9 children with MMHL showed phonological impairment (scores below the 10th percentile on two or more indicators on measures that included phonological discrimination, phonological awareness, and nonword repetition). These same children had poorer expressive and receptive vocabulary and had higher hearing thresholds than the other 10 children (without phonological impairment). Nonword repetition was problematic for all children with MMHL, differing significantly from the control group but not from the SLI group. Phonological impairment in the MMHL population did not entail the pervasive language and literacy difficulties that characterized the SLI population: Indeed, phonological problems can apparently "be dissociated from other language skills in the hearing impaired" (p. 338).

Norbury, Bishop, and Briscoe (2001, 2002), for English-speaking children, and Tuller and Jakubowicz (2004), for French-speaking children, compared morphosyntactic performance of children with MMHL with that of children with SLI. As argued in these studies, comparison of children with MMHL and children with SLI is of considerable interest. For both of these groups, language difficulties can be dissociated from factors such as bilingualism with sign language or the use of a manual code (cued speech), both of which make comparison with severe or profound HL more complicated. Although the acquisition context is in this respect similar, the source of language impairment is different: it is well identified in the case of HL but much less well identified in the case of SLI. Norbury et al. found that 21%–22% of children with MMHL (who were the same as in the Briscoe et al., 2001, study) displayed deficits as severe as those found in the children with SLI, with deficits in sentence comprehension and production of verbal inflection, as well as low scores on all standardized language measures. The authors underlined the high variability in performance among children with MMHL. An age effect on language performance was found (older children performing better than younger), but no relation could be established between degree of HL (or age of HL detection) and language scores. Tuller and Jakubowicz (see also Abily & Chopin, 2002; Delage & Hurel, 2003; Guillemot, 2002; Lameloise & Louat, 2002) explored morphosyntactic development in 20 French-speaking children ages 6–13 with MMHL (PTA 37 dB–64 dB) via elicited production and comprehension tasks testing mastery of specific grammatical items (pronominal clitics, verb tense, and definite determiners). It was found that these children, as a group, displayed significant difficulties, but not for all items tested. Although all items tested had a reduced surface form (light monosyllables and therefore short phonetic duration), difficulties were specific to certain forms and especially to accusative pronoun clitics (which are functionally analogous to English direct object pronouns). These items, which were difficult for children with MMHL, were also those which were less well mastered by young typically developing children and which were deficient in children with SLI. High intersubject variation was observed and was found to be related to age (older children performing better than younger) but not to degree of HL, age of detection, or age of hearing aid fitting. Finally, although performance increased with age, some of the older children had scores as low as those found for the most impaired children with SLI, suggesting that these children might have a double handicap (auditory and "specific" to language).

Friedmann and Szterman (2006) also found syntactic deficits in three experiments administered to Hebrew-speaking children with moderate, severe, and profound HL, ages 7;7–11;3. The number of participants with moderate HL, whose PTA ranged from 45 dB to 65 dB, included in these studies varied depending on the experimental task: 12/20 and 9/14 children. As a group and compared with control children, the children with HL failed to understand object relatives and object–verb–subject topicalization sentences. They avoided producing sentences with syntactic movement or produced ungrammatical sentences. Whereas early detection of HL, early intervention, and early hearing aid fitting were positively correlated with performance on sentence comprehension tasks, syntactic comprehension did not correlate with degree of HL.

In summary, language impairment has been reported for children with MMHL in the areas of phonology, vocabulary, and morphosyntax. Most studies underline the fact that there is very high intersubject variation. Degree of HL has generally not been found to be correlated with language performance (except by Briscoe et al., 2001, and only on certain phonological measures). However, an age effect was highlighted by Norbury et al. (2001, 2002) and Tuller and Jakubowicz (2004). These observations raise the issue of normalization of language with age. Studies of language in adolescents with MMHL might provide an answer to this question.

Although studies of long-term effects at adolescence in atypical language development are becoming increasingly frequent, most of these concern SLI (see Reed, 2005, for a review). To our knowledge, no studies have focused on language outcomes in adolescents with MMHL. Do adolescents with HL display late normalization, or, on the contrary, do they show long-term effects of the limited and/or distorted linguistic input they have experienced during childhood? For adolescents with childhood SLI, long-term effects in written and oral language are well documented. For example, Stothard, Snowling, Bishop, Chipchase, and Kaplan (1998) found that adolescents with SLI (15–16 years old) with a preschool diagnosis of SLI had significant deficits in oral and written language. In particular, 95% of these adolescents had remaining written language impairment. Studies comparing language impairment in children with MMHL and in children with SLI have found remarkable similarities (Briscoe et al., 2001; Norbury et al., 2001, 2002; Tuller & Jakubowicz, 2004). Does this comparison yield the same results when MMHL and SLI are compared at the age of adolescence? If similarities do continue at this age, are they qualitative and/or quantitative? The majority of studies presented earlier found no relation between severity of HL and severity of language impairment. Is this also the case for adolescents with HL?

We sought to explore the nature of the link between HL and language impairment by focusing on two factors that have given clear results in the literature on language development in children with MMHL: age, which is generally correlated to language performance, and degree of HL, which is generally not. Whereas the existing literature is devoted to children, sometimes associated with adolescents in a larger group, we hoped to explore these variables by focusing exclusively on adolescents. Investigation of language performance after childhood, when maturation of language competence is complete, should offer an additional perspective under which these questions can be explored as well as offer the possibility of looking at just how disturbing mild-to-moderate HL is for overall language development. In other words, does MMHL cause only developmental difficulties, or does it have more lasting effects on language? What proportion of adolescents with MMHL show signs of language impairment, and which language areas are affected? Does language performance correlate with degree of HL (or age of HL detection/hearing aid fitting)? Although a few older children (11–13 years old) in the Tuller and Jakubowicz (2004) study had language deficits as severe as those found in children with SLI, this study and that by Norbury et al. (2001, 2002) showed a clear age effect on morphosyntactic performance, with language performance increasing with age. It seems therefore imaginable that more, if not all, adolescents with MMHL will have normalized language performance than children with MMHL. We also expect that adolescents with MMHL who continue to have impaired language will show the same pattern of impairment as adolescents with SLI. Indeed, as we have seen, comparative studies of children with MMHL and SLI found similarity in type of impairment (Briscoe et al., 2001; Norbury et al., 2001, 2002; Tuller & Jakubowicz, 2004).

Method

Participants

Nineteen monolingual French-speaking adolescents (9 boys and 10 girls) ages 11;9–15;1 (M = 13;8, SD = 1;1) with prelingual, bilateral, sensorineural MMHL ranging from 27 dB to 69 dB (M = 46.9, SD = 11.6) were recruited via the otolaryngology service of a university pediatric hospital and a center that provides services for children with deafness. Inclusion criteria were age (ages 11–15), degree, and type of HL (bilateral, sensorineural, prelingual, with PTA between 20 dB and 70 dB). All adolescents with bilingual homes, associated syndromes, mental retardation, and other difficulties were excluded. A genetic origin was assumed for 12 participants (who had family histories of deafness). Age of HL detection varied from age 1;6 to 7;2 (M = 4;1, SD = 1;6). Four participants had repeated one class, and 4 others had repeated two classes, a rate much higher than average for adolescents in the French school system. Nearly all (N = 17) had received speech-language therapy, and 8 were currently in therapy. The duration of therapy varied from 6 months to 13 years. Nonverbal reasoning was controlled via a spatial problem-solving task (similar to Raven's Progressive Matrixes) that is part of the BILO Battery (Bilan informatisé du langage oral et écrit [Computerized battery for oral language]; Khomsi, in press). None of the 19 adolescents scored below the fifth percentile. The characteristics of the population are summarized in Table 1.

These adolescents with MMHL were compared with several groups of typically developing adolescents and a group of 12 adolescents with SLI (also studied by Henry, 2004), ages 11–19 (M = 14;8, SD = 2;5). These 12 monolingual adolescents with SLI were tested for all language measures. All of these adolescents were diagnosed in childhood (M = age 7;6, SD = age 1;7) at the same university teaching hospital, which uses typical inclusionary and exclusionary criteria for SLI (including Performance IQ > 70, normal hearing, absence of neurological damage, psychological or psychiatric impairment, no socio-affective deprivation). SLI adolescents were not matched with adolescents with MMHL in gender and school level, but they were matched in terms of mean age (ages of SLI and MMHL participants did not differ: U = 101.5, p = .4). All participants were tested for nonverbal reasoning on the same test as the adolescents with MMHL: Two participants performed below 1.65 SD but were nonetheless included on the basis of their medical diagnosis, as presented previously.

Two groups of typically developing children and adolescents served as controls. The standardized tests (the BILO Battery) were standardized over a population of 272 primary and middle school students (ages 5–16). Fifty-two adolescents from this standardization population, referred to as the "typically developing 11–15-year-olds" (TD 11–15 group), were matched to the adolescents with MMHL in age (age range = 11;8–15;6 years; M = 13;7, SD = 1;2), gender, and school level, and therefore included children at grade level as well as children behind grade level, as in the MMHL population. All individuals in the standardization population were recruited in ordinary schools with no screening for language impairment or learning disabilities, and thus could in principle include participants with minimal HL or language learning disabilities.

For the experimental probe, 12 monolingual 11-year-olds (6 boys and 6 girls; mean age = 11;4, SD = 0;4), the age of the youngest adolescents with MMHL and SLI, were randomly selected from a middle school class, after exclusion of children who had had language therapy or who were behind grade level. They formed the second control group.

Table 1. Characteristics of the population.

Participants (pseudonyms)	Age (years; months)	Pure-Tone Average (dB)	Age of Hearing Loss Detection	Age of Hearing Aid Fitting	No. of Years of Speech-Language Therapy	No. of School Years Repeated	Spatial Problem-Solving Task (in standard deviation)
Viviane	11;9	52.3	4;6	4;7	1	0	−0.02
Nathan	12;0	27.1	7;2	9;0	4;1	1	0.45
Thomas	12;0	43.3	4;9	4;9	5;8	0	0.45
Louise	12;6	45.2	3;5	3;10	8	0	0.45
Méline	12;10	41.2	2;6	2;10	8	0	−0.65
Maud	13;1	39.2	4;2	4;11	0	0	0.27
Jennifer	13;3	67.7	4;4	6;9	8;10	2	0.14
Tim	13;4	64.3	4;0	5;0	8	2	0.61
Matthieu	13;8	40.9	5;6	6;0	1	1	0.63
Antoine	13;10	48.8	3;6	4;0	13	1	−1.38
Kimberley	14;2	37.9	5;7	6;0	5	2	−0.10
Claire	14;3	33.3	3;7	4;0	0	0	2.32
Boris	14;6	69.2	2;3	2;5	8;6	2	−0.83
Kim	14;7	54.4	2;0	3;0	9	0	−0.66
Charlene	14;7	59.2	1;6	2;0	11	0	2.88
Michaël	14;8	45.9	6;0	7;3	6;6	1	−1.38
Manon	14;8	38.8	3;10	6;7	0	0	2.51
Roland	15;0	42.6	5;10	6;2	0;6	0	−1.22
Rémi	15;1	40	3;10	9;0	6	0	3.07
M	13;8	46.9	4;1	5;2	5;6		
SD	1;1	11,6	1;6	2	4;1		

Materials

Language assessment. Spoken language and literacy skills were assessed via a set of seven standardized, computerized language tests from a battery of oral and written language tests: the BILO Battery (Khomsi, in press). In this battery, phonology (as well as phonological memory) is assessed by a word repetition task of 42 (real) words of increasing length and/or complexity (*hélicoptère* "helicopter," *excentrique* "eccentric," *enchevètrement* "tangle," etc.). Expressive vocabulary is assessed using a classical naming task. Expressive grammar is evaluated using a sentence completion task: The child listens to a sentence corresponding to a picture on the screen and then has to complete the end of the sentence to fit with the picture (e.g., *Ici, le chien boit son lait; là les chiens*…[*boivent leur lait*]/"Here the dog is drinking his milk; there, the dogs … [are drinking their milk]"). This test assesses ability to produce a variety of specific grammatical morphemes: nominal, adjectival and verbal inflexion, irregular plurals, prepositions, passive structure, and pronominal clitics. Reading is assessed using a timed task in which the child has to read, in 60 s, as many words as possible from a list of words of increasing difficulty. Spelling is tested using a word identification task. The child is presented with words that are correct, homophonic misspellings (e.g., *mézon* instead of correct *maison* "house"), nonhomophonic misspellings (e.g., *binyclette* instead of correct *bicyclette* "bicycle"), or merely words belonging to the same semantic field (e.g., *poulet* "chicken" for a picture of a duck). The task is to decide (by giving a yes or no answer) whether the word corresponding to the picture is correct or not. In addition, lexical judgment and grammatical judgment tasks are included in the battery. These tests assess the ability to judge the well-formedness of words and sentences, which requires both metalinguistic abilities and morphosyntactic and lexical knowledge. Lexical judgment consists of deciding whether there is concordance between a word (noun or verb) and a picture presented simultaneously. Grammatical judgment consists of deciding whether a sentence corresponding to a picture is grammatically correct (by giving a yes or no answer).

Specific difficulty with the production of accusative clitic pronouns in French, illustrated in Example 1c, has been shown for children with MMHL (Tuller & Jakubowicz, 2004), for children with SLI (see, e.g., Grüter, 2005; Hamann et al., 2003; Jakubowicz, Nash, Rigaut, & Gerard, 1998; Paradis, 2004; Paradis, Crago, & Genesee, 2003) and for young typically developing children (Chillier et al., 2001; Hamann, Rizzi, & Frauenfelder, 1996; Jakubowicz & Rigaut, 2000). These studies have shown that these particular clitic pronouns are more difficult to produce than both reflexive object clitics, illustrated in Example 1b and nominative (subject) clitics, illustrated in Example 1a:

1a. **Il** lave Max. — **Nominative clitic**
He washes Max.
"**He** washes Max."

b. Max **se** lave. — **Reflexive clitic**
Max himself washes.
"Max washes **himself**."

c. Max **le** lave. — **Accusative clitic**
Max him/it washes.
"Max washes **him/it**."

A consensus has emerged in the literature that suggests that accusative clitics constitute a clinical marker of developmental language impairment in French (see, e.g., Hamann et al., 2003; Jakubowicz et al., 1998; Paradis et al., 2003). To test clitic pronoun production in adolescents, we developed an experimental production probe of pronoun clitics eliciting production of nominative, reflexive, and accusative clitics in the first and third person singular by requiring a response to a question about a picture appearing on the computer screen, as in Examples 2 and 3:

2. Experimenter: *Que fait le monsieur avec la voiture?* "What is the man doing with the car?" Expected response: *Il la lave*. "He's washing it."
3. Experimenter: *Lui, il dit: Eh Thomas, que fait le chien? Toi, tu es Thomas, dis-moi ce que tu réponds?* "He says: Thomas, what is the dog doing? You are Thomas, tell me how you answer?" Expected response: *Il me lèche.* "It's licking me."

Materials used, and comparison populations, are summarized in Table 2. Adolescents with MMHL were evaluated individually at home ($n = 11$) or in a center ($n = 8$), with written parental consent. Cues were repeated at the request of the participants, all of whom wore their hearing aids.

Procedure for defining language impairment. Scores on standardized tests were converted to z scores. To determine what proportion of children were experiencing language impairment and which language areas were affected, it was necessary to adopt a criterion for deviance. Indeed, one of our goals was to determine if there were more language-impaired participants in the MMHL group than in a typically developing population. Various thresholds for language impairment are used in clinical and research settings. Although there is no consensus in the literature, many authors use the threshold of –1 *SD* (Briscoe et al., 2001) or –1.65 *SD* (Monjauze, Tuller, Hommet, Barthez, & Khomsi, 2005; Ramus et al., 2003). We chose the second threshold, which corresponds to the fifth percentile in a normal distribution, in order to highlight clear language deficits. Language impairment was defined as scores on two or more standardized language subtests below –1.65 *SD*. Spearman rank

Table 2. Materials and control groups.

	Variables tested	SLI participants	Controls
BILO Battery (standardized battery of oral and written language tests)	Production: phonology, vocabulary, grammar Oral comprehension: picture–sentence matching Judgment: lexical and grammatical Written language: reading and spelling	SLI 11–19 (*n* = 12) matched for mean age with MMHL	TD 11–15 (*n* = 52) matched (age, gender, school level) with MMHL
Production Probe of Pronoun Clitics (experimental probe)	Production of nominative, reflexive, and accusative clitics	SLI 11–19 (*n* = 12) matched for mean age with MMHL	TD 11 (*n* = 12) not matched

Note. SLI = specific language impairment; TD = typically developing; MMHL = mild-to-moderate hearing loss; BILO = Bilan informatisé du langage oral et écrit [Computerized battery for oral language].

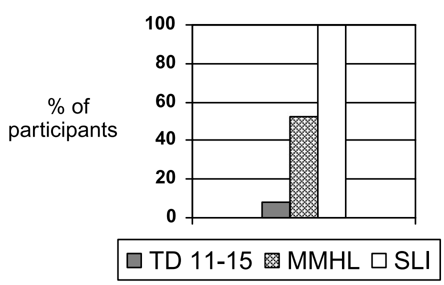
correlation coefficients (r_s) were used for correlation analyses, and language performance of subgroups was compared via a one-way analysis of variance (ANOVA), completed by the Mann–Whitney nonparametric test for independent samples. The Wilcoxon nonparametric test was used for within-group analysis. Statistical test results that revealed nonsignificant differences are not reported in detail.

Results

Language Impairment on Standardized Tests

Ten of the 19 adolescents with MMHL (52.6%) obtained very low scores, below 1.65 *SD* on two or more language tests (see Figure 1). The proportion of adolescents that fulfilled our criterion for language impairment in the TD 11–15 group was 7.7% (4 of the 52 participants had two or more scores below –1.65 *SD*). The proportion of control participants having scores <–1.65 *SD* was thus considerably larger in the MMHL group (52.6%). This is particularly striking given the fact that the control group was set up so that it contained as many adolescents experiencing difficulty at school as the MMHL group: Forty-eight percent of the control group and 42.1% of the MMHL group were behind grade level (the difference between the two groups was not significant: $U = 474$, $p = .8$).

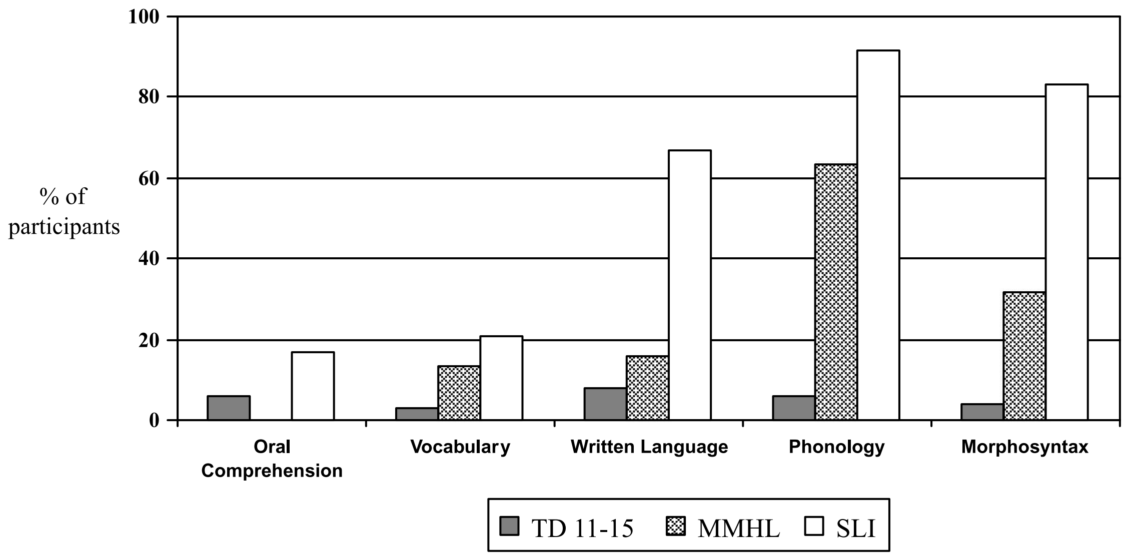
Figure 1. Percentage of participants having two or more language measures <–1.65 *SD*. TD = typically developing; MMHL = mild-to-moderate hearing loss; SLI = specific language impairment.



Turning now to adolescents with SLI, Figure 1 shows that these adolescents had very low scores: All of them performed below 1.65 *SD* on two or more language tests. To identify which areas were most affected in hearing-impaired adolescents, we compared the number of adolescents performing below –1.65 *SD* by language area. Expressive vocabulary and lexical judgment scores constitute the vocabulary domain, reading and spelling constitute written language, and expressive grammar, and grammatical judgment constitute the morphosyntax domain. (For each domain, the percentages of adolescents performing below –1.65 *SD* on the subtests were averaged.) These percentages for MMHL participants, SLI participants, and control participants are presented in Figure 2.

Adolescents with MMHL had particular difficulties on phonology (63.2% of participants had scores <–1.65 *SD*) and morphosyntax (31.6% of participants had scores <–1.65 *SD* for both expressive grammar and grammatical judgment tasks). The scores in these two areas were strongly correlated (expressive grammar and phonology: $r_s = .69$, $p < .001$; grammatical judgment and phonology: $r_s = .68$, $p < .01$). Oral comprehension, written language, and vocabulary seem to be relatively unaffected. Adolescents with SLI also showed particular deficits in the areas of phonology and morphosyntax (91.7% had scores <–1.65 *SD* for phonology, 83.3% for morphosyntax). This pattern was not observed in the control group. To test group effect, we used a one-way ANOVA with three independent groups (MMHL, SLI, and controls) on eight dependent variables (standardized test scores). A group effect was apparent for morphosyntax (grammatical judgment, $F[2, 77] = 25.4$, $p < .001$, and expressive grammar,

Figure 2. Percentage of participants with scores <–1.65 *SD* for each language area.



$F[2, 77] = 6.5, p < .01$); phonology ($F[2, 77] = 43.9, p < .001$); and written language (reading, $F[2, 77] = 30.5, p < .001$, and spelling, $F[2, 77] = 8.7, p < .001$). Indeed, scores of participants with MMHL were significantly lower than those of controls on grammatical judgment ($U = 330$, $p < .05$) and phonology ($U = 223.5, p < .001$). On the other hand, MMHL scores were significantly higher than corresponding SLI scores, except on lexical tasks and oral comprehension.

Interestingly, while written language appeared to be the area with the lowest scores in the TD 11–15 control group, and while this area was also affected in adolescents with SLI, it was less affected in the MMHL group. No significant difference appeared between controls and participants with MMHL for written language, whereas scores of adolescents with SLI were significantly lower than those of the other participants: Scores of adolescents with SLI were lower than those of adolescents with MMHL (for reading: $U = 22, p < .001$; for spelling: $U = 26.5, p < .001$) and than those of controls (for reading: $U = 31.5, p < .001$; for spelling: $U = 77, p < .001$).

Language Impairment on the Experimental Probe

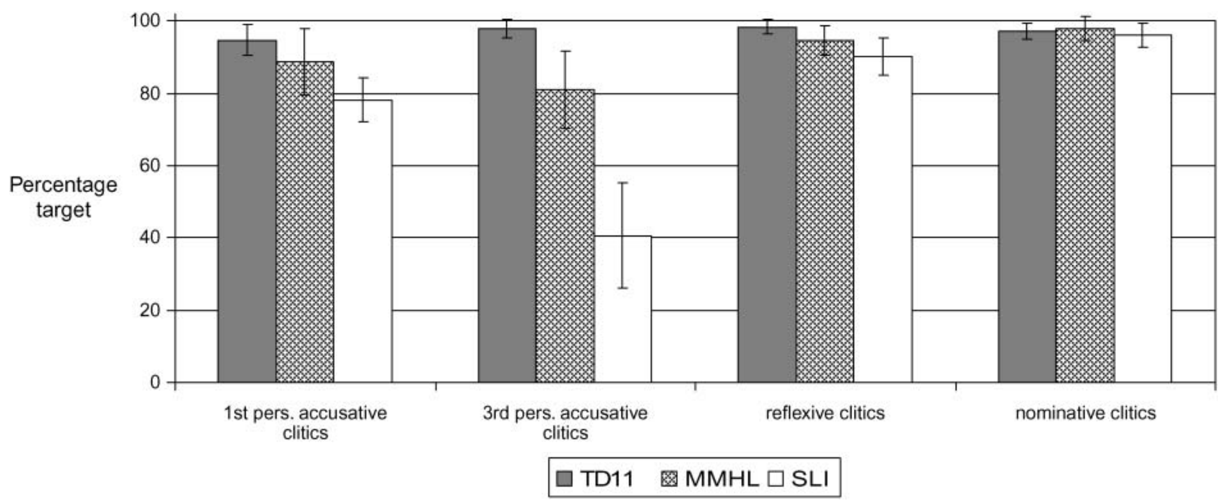
The performance of the MMHL adolescents for the production of clitic pronouns was evaluated by comparison with a group of 12 typically developing 11-year-olds (TD 11). Figure 3 presents the results of the adolescents with MMHL, the adolescents with SLI, and the control participants.

The scores in this figure represent clitic production, including therefore both correctly produced clitics as well as clitics produced with a gender or person error. The scores of the adolescents with MMHL are close to those of the control participants for reflexive and nominative clitics. On the other hand, the production of accusative clitics, and especially in the third person, is problematic for participants in both groups of atypical learners (with MMHL and with SLI), though there is considerable intersubject variability (*SD*s = 21.4 and 29.2, respectively): For participants with MMHL, scores ranged from 37.5% to 100% (for participants with SLI: 0%–100%). Moreover, a one-way ANOVA showed a group effect for this linguistic variable, $F(2, 37) = 24.5, p < .001$. Thus, the adolescents with MMHL produced significantly fewer (third person) accusative clitics ($M = 80.9$ %) than control participants, whose mean was 97.9 % ($U = 54$, $p < .05$). Moreover, they produced significantly fewer accusative clitics (84.9% for first person and third person) than reflexive clitics ($M = 94.7\%$), $T = 38, p < .001$, which were produced less often than nominative clitics ($M = 98\%$), $T = 20, p < .05$. An identical pattern was found for adolescents with SLI: They produced significantly fewer third person accusative clitics (40.6%) than TD 11 participants ($U = 7$, $p < .001$), but they also performed significantly worse on this item than the adolescents with MMHL ($U = 31.5, p < .001$).

When participants with MMHL did not produce the (third person) accusative clitic, they essentially produced lexical noun phrases (8.6% of responses), as in Example 4, or omitted the object altogether, resulting in an ungrammatical utterance (5.9% of responses), as in Example 5 (as indicated by the asterisk):

4. *Que fait le médecin avec le bébé*? "What's the doctor doing with the baby?" *Il pèse le bébé*. "He's weighing

Figure 3. Production rate for accusative (first person and third person), reflexive, and nominative clitics. Error bars represent standard deviations.



the baby." (Expected response: *Il le pèse* He's weighing him").

5. *Que fait Marie avec le fil du téléphone*? What's Mary doing with the phone line? **Elle coupe*. "She's cutting." (Expected response: *Elle le coupe* "She's cutting it").

At the syntactic level, answers containing a lexical noun phrase are correct, but they are discursively infelicitous because the patient is already expressed in the question ("What is the doctor doing to **the baby**?"). This type of answer arguably constitutes a compensatory mechanism for participants who do not sufficiently control the production of accusative clitics. Object omission, on the other hand, constitutes, at least in this context, an ungrammatical answer. Omission was also found in adolescents with SLI (rate of 15.6% on average), but never in control participants.

Correlations Between Language Scores and Clinical Variables

To determine if there were links between clinical variables and language performance in participants with MMHL, we performed Spearman correlation tests. No significant correlation was found between language scores and either age or nonverbal level (as measured by the spatial problem-solving task). However, the number of years of speech therapy was linked to three standardized language measures: the global language score (the mean of all scores; $r_s = -.45, p < .05$), expressive grammar ($r_s = -.55, p < .05$), and word repetition ($r_s = -.58, p < .01$). Adolescents followed for longer periods (and thus in principle presenting more severe linguistic disorders) obtained weaker scores on these measures. No relation could be established between the age of HL detection or age of hearing aid fitting and language performance. However, links were found with tonal audiometry: A correlation was observed between average HL (PTA) and performance in expressive grammar ($r_s = -.51, p < .05$) and in word repetition ($r_s = -.61, p < .01$), with participants who presented a higher degree of HL performing worse on both of these measures. This result was confirmed when adolescents with scores <–1.65 *SD* on these two tasks were compared with those who scored above this level: For these two measures, the mean HL of the lower scoring subgroup was significantly worse than that of the higher scoring subgroup ($U = 13, p < .05$, for expressive grammar; $U = 17, p < .05$, for word repetition). Thus, language impairment in morphosyntax and phonology was related to severity of HL in this study, a result not found in the majority of studies of children with MMHL. Finally, we found significant differences between the participants who had repeated one or two classes and participants who were at grade level, the latter performing better than the former on the following tasks: expressive grammar ($U = 8.5, p < .01$) and reading ($U = 20, p < .05$) on standardized tests and production of first person accusative clitics ($U = 17.5, p < .05$) and third person accusative clitics ($U = 8, p < .01$), omission of third person accusative clitics ($U = 16.5, p < .05$) in the experimental task.

Discussion

We have sought here to determine whether adolescents with MMHL continue to have language problems, and if so in what proportion, to what degree, and in what areas. The main finding of this study of 19 adolescents with MMHL is that impaired language performance was observed at adolescence in proportions not found in typically developing populations. Impaired performance was found on both standardized tests and in an experimental probe focusing on specific grammatical items. Indeed, 10 of the participants studied showed very weak language performance, with scores below 1.65 *SD* on two or more language tests in a standardized battery. This same level was found for only 7.7% of participants in the control group, who were matched in age, gender, and, importantly, grade level at school with the MMHL adolescents (meaning thus that the high number of adolescents below grade level in the MMHL group was also matched). Interestingly, as an anonymous reviewer pointed out, this proportion of participants with very weak language performance found in the control group is completely in accordance with Tomblin et al. (1997), who estimated SLI prevalence to range up to 7%.

The fact that more than half of the adolescents with MMHL displayed relatively severe long-term impairment would therefore seem to exclude the hypothesis of generalized normalization of language in adolescence in this population. Earlier studies of children with MMHL have also identified a sizeable proportion of children with language impairment. Thus, Gilbertson and Kamhi (1995) reported difficulties for half of the children with moderate HL who they tested in a protocol that evaluated lexical acquisition (and these same children also had low scores on vocabulary tests and on phonological processing tasks). Tuller and Jakubowicz (2004) found specific difficulties in morphosyntax for more than half the children with moderate HL who they studied: Fifty-five percent of the children had a production rate on (third person) accusative clitics lower than 50%. Briscoe et al. (2001) and Norbury et al. (2001, 2002) found that 21%–22% of the children with MMHL who they studied displayed difficulties in morphosyntax (production and comprehension), and 50% had significant phonological deficits. Although the materials used in these studies and the criteria used to identify language impairment were different (and thus cross-study comparison is merely indicative), we can observe that the affected areas are the same (morphosyntax and phonology) and the proportion of affected participants is substantial. This is precisely what we found for adolescents: 31.6% of the adolescents with MMHL had low scores (<–1.65 *SD*) on tests of morphosyntax and 63.2% on a phonological test. Language impairment thus apparently is not resolved in adolescence, even though there is clearly language progression during development (in that adolescents do not appear to be further behind age controls than are children).

The weakest scores of the adolescents with MMHL were in the areas of morphosyntax and phonology. The adolescents with SLI who were compared with the adolescents with MMHL displayed this same pattern. In both of these groups, scores on morphosyntax and scores on phonology were strongly correlated. It would appear that these two linguistic modules are particularly vulnerable in atypical language development generally and not specifically in the case of HL. This result, which replicates the findings of previous studies restricted to comparison of children with MMHL and children with SLI, might appear to be compatible with the idea that MMHL and SLI yield similar deficits due to the hypothesized existence of abnormal auditory temporal processing in SLI, a hypothesis assumed by some researchers (Tallal, 1976; Wright et al., 1997) and which could be taken to suggest that this could be a similarity with HL. This conclusion, however, would be hasty on two grounds. First, not all individuals with SLI have problems with auditory processing (see, e.g., Bishop & McArthur, 2004), and not all individuals with auditory processing deficits have SLI (Bishop, Carlyon, Deeks, & Bishop, 1999). Second, there is mounting evidence coming from comparative studies of children for whom the source of language impairment is very different that group differences are quantitative rather than qualitative (see, e.g., the studies in Reilly and Wulfeck [2004] that compare early focal brain damage, Williams syndrome, late talkers, Down syndrome, and SLI). In other words, identical patterns of linguistic impairment do not entail identical etiology.

There is one result that did differentiate adolescents with MMHL and those with SLI. Although written language was clearly affected in adolescents with SLI, relatively few adolescents with MMHL had low scores in this area. This result was also found by Briscoe et al. (2001) for children with MMHL, though the majority of these children had mild HL. We note, first, that the tests we used to evaluate written language were limited to a timed reading task and a written word identification task, and thus morphosyntactic skills are not involved. It is imaginable that reading comprehension and text production would prove to be much more difficult for these adolescents, given their poor results in morphosyntax. Furthermore, individuals with HL most likely compensate their oral difficulties by relying on written language (and this is explicitly part of speech-language therapy directed at these children), which provides a more reliable model than the degraded oral input. Reading words and recognizing words is not a problem for most of these adolescents, who have learned to use written support to overcome the phonological problems that arise in oral word repetition tasks.

The results of the experimental probe focusing on pronominal clitics also show that a significant proportion of adolescents with MMHL continue to have difficulties with accusative clitics, grammatical items widely identified as being particularly difficult for young learners of French (Chillier et al., 2001; Hamann et al., 1996; Jakubowicz & Rigaut, 2000). Indeed, it has been proposed that these may constitute a clinical marker for French children with SLI (Hamann et al., 2003; Jakubowicz et al., 1998; Paradis et al., 2003). Our findings suggest that production of accusative clitics constitutes a pertinent probe of language difficulty not only in children, but also in adolescents. We found a significant difference between typically developing 11-year-olds and adolescents with MMHL with regard to accusative clitics (third person) production. Tuller and Jakubowicz (2004), in a study of 20 children with moderate HL, found a production rate of 36% for this item for children ages 6–8 and 66.7% for those ages 9–13. While remaining extremely careful in the interpretation of these results (protocols and populations being different), we note that performance appears to progress with age: The production rate of these MMHL adolescents (80.9%) is higher than that of the younger children. Yet, although the MMHL adolescents, as a group, show better performance than the younger participants, a sizable number continue to perform well below typically developing 11-year-olds. Once again, we conclude that language normalization at adolescence is far from being the general case for individuals with MMHL.

Why do some, but not all, individuals with mild-to-moderate HL have significant language impairment? Gilbertson and Kamhi (1995) suggested that certain children presenting language impairment might, in addition to their HL, have SLI and might therefore be more accurately characterized as "language-impaired children with a HL" (p. 640). This question was also raised by Tuller and Jakubowicz (2004), who entertained the possible plurality of deficits (comorbid disorders) in children with MMHL. As Gilbertson and Kamhi pointed out (see also Norbury et al., 2001), it seems obvious that comorbidity cannot fully account for the proportion of participants experiencing severe language difficulties. Indeed, the proportion of language difficulties found in the present study (52.6%) is much higher than would be expected if the cause were uniquely due to SLI, whose prevalence is estimated to range up to 7% (Tomblin et al., 1997). Clearly, HL is at least part of the problem, but just how HL is related to language impairment is a difficult question. A direct relation would seem to be excluded by the fact that most studies have found no relation between degree of HL and language impairment, and, moreover, some individuals with MMHL show no language impairment.

The idea of an indirect link between HL and language impairment raises, of course, the question of the intervening factor(s). HL may weaken or put strain on performance systems (e.g., due to increased attention requirements) that interact with language competence. There may also be a timing factor on language competence itself. Indeed, we would like to suggest that one of the factors that might also be playing a role here involves the concept of a critical period for language acquisition. First of all, it seems reasonable to assume that restricted and impoverished input slows down language development. Protracted language development entails that at the end of the primary years for core language acquisition, the so-called critical period of the first 6 to 7 years of life, acquisition is not complete (or not fully automatic). In other words, atypical development in early childhood may have long-lasting effects that can be observed in adolescence. Studies of critical period effects have shown that it is formal aspects of language—phonology and syntax—that are vulnerable, whereas lexical and semantic performance is much less (or not) affected (see Newport, Bavelier, & Neville, 2001, for a review of the literature). Thus, for example, Weber-Fox and Neville (1999) in a study of second language immersion showed that syntactic proficiency was more affected than lexical (or semantic) judgment accuracy, the former decreasing even in individuals with first exposure at ages 7–10 and the latter decreasing only for individuals with exposure after age 16. If MMHL entails, for many participants at least, protracted development of language, it is not surprising that their difficulties are concentrated in the areas of phonology and in morphosyntax, the formal aspects of language.

However, as we have repeatedly underlined, not all adolescents with MMHL show long-term effects: One constant property of this population is the enormous intersubject variability. We return once again to the question of why all of these adolescents do not show critical period effects. When we looked for relations between clinical variables and language performance, we found no correlation with nonverbal level, as measured by a spatial problem-solving task, and thus it does not seem to be the case that intersubject variation could be explained by something like general intelligence. Participants who were behind grade level had weaker scores in some language areas than participants who were at grade level, and a correlation was found between certain language measures and number of years of speech-language therapy. This result, again, is not surprising: The language impairment found in this population, as measured by standardized tests as well as the experimental probe of clitic production, is severe enough to necessitate therapy and to be a likely source of delay at school.

A factor of potential interest for the question of why not all adolescents with MMHL show significant critical period effects in their language performance concerns the length of the period of unaided HL. Thus, the language development of children whose HL is detected earlier, and thus who are fitted with hearing aids earlier, should in principle be less disturbed than that of children whose HL is detected much later (say, at age 6 or 7). Besides the fact that the success of auditory correction varies considerably from child to child, there is that fact that age of HL detection is generally inversely correlated with degree of HL: The greater the HL, the earlier it is detected, but, also, the more degraded is the input, due to HL. In other words, the children with a longer period of unaided HL are also those for whom hearing is less degraded. It is therefore unsurprising that we found no correlation between either age of HL detection or age of hearing aid fitting and language performance.

Interestingly, no correlation was found between language performance and age in this group of 11- to 15-year-olds. This is in contrast with studies of children with MMHL (5- to 10-year-olds in Briscoe, 2001, and Norbury et al., 2001, 2002; 6- to 13-year-olds in Tuller & Jakubowicz, 2004). We suggest that this difference may indicate that language systems are stabilizing in the adolescents and therefore that age no longer predicts intersubject variability. We believe this result may be linked to the other important difference between the results presented here and those found for children with MMHL: the nature of the relation between degree of HL and language performance. While, not surprisingly, degree of HL has been found to be correlated with phonological performance in MMHL children (Briscoe et al., 2001), such a correlation has never been found, to our knowledge, for morphosyntax. Various hypotheses have been proposed to explain why, quite generally, this correlation is not observed. For Gilbertson and Kamhi (1995), who found that the children they studied who had higher language proficiency also had higher nonverbal IQ, children who performed better "probably have above-average cognitive and linguistic processing skills as well as supportive and nurturing learning environments" (p. 640). Likewise, Blamey et al. (2001) suggested that because children with HL cannot rely on incidental hearing as a major source of new information for language development because of their degraded audition, other factors not influenced by degree of HL may have an overwhelming effect on development (environmental factors such as quality and quantity of input, teaching, and feedback, as well as ability to use visual information such as lipreading and intrinsic factors such as intelligence). Stelmachowicz et al. (2004) suggest that signal audibility is not sufficient to ensure novel word learning (the measure they studied) that is in fact "influenced by a variety of auditory and nonauditory factors" (p. 54). While we were not able to control for all of these factors, we did confirm the lack of correlation between language performance and a measure of general intelligence, already found by Norbury et al. (2002), the explanation most often alluded to in the literature.

Although we fully acknowledge the complexity of the relation between HL and language performance, we would like to suggest an additional factor that may allow for an explanation as to why degree of HL is correlated with language performance at adolescence but not in childhood. Our speculation is that differences in developmental rhythm—that is, (normal) variation from one child to another—obscure the variation in HL during childhood. Maturation of language, just like other maturational processes, is subject to variation from one individual to another, some developing slower than others. At least some aspects of variation clearly cannot be attributed to external factors and therefore can be attributed to differences in rate of maturation. This difference between children disappears as maturation of language is completed, allowing other potential sources of variability to surface. We suggest that HL is one of them. In other words, variation in developmental rhythms obscures the effects of variation in HL. During adolescence, when linguistic development is largely completed, the effect of degree of HL can be observed, particularly in areas that are vulnerable to critical period effects (phonology and morphosyntax).

In conclusion, we have excluded the hypothesis of general language normalization at adolescence: Selective linguistic disorders persisted in more than half of adolescents with MMHL. The relation between HL and language impairment is complex, appearing to be linked to a variety of factors. This is an unsurprising result given that language competence is not directly affected by deafness, yet deafness most definitely affects performance systems that interact with language competence. Competence, therefore, remains immature for many such individuals, plausibly constituting a critical period effect. Degree of HL, we believe, is just one factor in ultimate language outcome. The fact that the effect of this variable becomes clear only at adolescence might be due to a combination of critical period effects with differences in maturational rhythm during childhood. A longitudinal study focusing on linguistic deficits in individuals with MMHL during the period covering both childhood and adolescence should allow investigation of this line of reasoning.

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