WISC–V

WECHSLER INTELLIGENCE SCALE FOR CHILDREN® – FIFTH EDITION

Technical Report #4

WISC–V Special Group Study: Children With Hearing Differences Who Utilize Spoken Language and Have Assistive Technology

September, 2016

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Introduction

Children with hearing differences[1] account for slightly over one percent of children receiving special education services in the United States (U.S. Government Accountability Office, 2011), with some studies estimating that as many as 14.9 percent of all U.S. children have a hearing difference when including children with unilateral, partial frequency, and mild hearing loss (Niskar et al., 1998). A hearing difference is a multifaceted phenomenon, and clinicians working with children with hearing differences must be aware of the heterogeneity of this population with regard to relevant factors, such as the age of onset of hearing loss, form(s) of communication, early language access, degree of hearing loss, use of assistive technology, and co-morbid conditions. Given the diversity within the population of individuals with hearing differences, interpreting assessment results requires great care and understanding of the individual child. Examiner knowledge and careful consideration of the potential impact that each of the above factors has on the child's development is important.

Consideration of the child's language and communication preferences and abilities is imperative for administration and interpretation of intellectual assessment measures. There is a wide variety of preferred communication methods among children with hearing differences

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[1] With respect to the variation of terminology used with this population (e.g., deaf, hard-of-hearing, hearing loss), the term "hearing differences" is utilized throughout this article to serve as a neutral placeholder, and it is meant to be inclusive of all perspectives and identities (i.e., cultural and medical) of this population. It defines an altered sensation of the physical act of hearing; this, in itself, is not a deprivation, but a difference.

(Day, Costa, & Raiford, 2015). As noted above, the population of children with hearing differences is a dynamic group that includes individuals with a range of hearing levels, educational backgrounds, and language considerations. Some children with hearing differences communicate using more than one method of communication, while other children have a clearly identified preferred primary language or communication method, and some have limited proficiency in any form of communication. The primary communication modalities/methods include American Sign Language (ASL) or other variation of a sign system, listening and spoken language, Cued Speech, and total communication, as well as a combination of two or more of these approaches. It is critical to note that within each of these categories, variability exists.

When evaluating a child's WISC–V test results, a strong understanding of the child's language and communication competency is critical and test results should be interpreted with caution. Some children may demonstrate strong competency in one or more language and communication modes, while others may still be developing language/communication competency. It is also possible that if the child has cognitive limitations, or was identified with a hearing difference later in development, the child may not have a strong language foundation. Assessment results should be understood and interpreted with an understanding of the expressive and receptive language capabilities of the child.

The current special group study focused on children who use listening and spoken English as a preferred communication modality, and utilize hearing aids and/or cochlear implants. When a child uses solely auditory modalities, spoken language is used without signs, gestures, or other visual representations of the spoken language. Appropriate and consistently functioning technology that allows auditory access to speech sounds, such as hearing aids or cochlear implants, is integral to the success of this communication choice. It should be noted that of the communication modalities listed above, this modality, along with Cued Speech, requires the least amount of modification considerations when administering the WISC–V. For a full review of subtest administration across communication modalities, see Day, Costa, and Raiford (2015).

While children who use auditory/oral modalities generally make use of spoken English, the child's ability to access auditory information should be clarified. This includes gathering background information on the child's hearing history, and requesting the child's most recent audiogram. A child who uses hearing aids or cochlear implants may have auditory access to speech sounds, but may still have difficulty discriminating between soft sounds (e.g., *C vs. 3*). In addition, the child may be taxed in detecting and understanding the speech of the examiner due to a hearing difference, even with the use of devices, which can result in testing fatigue. It should be noted that even when children with cochlear implants detect sounds in the mild to moderate range, the sounds they hear are limited in frequency resolution due the constraints of the device, and are different than the sounds heard by children fit with hearing aids. Hearing aids amplify sound and use natural hearing pathways, whereas the cochlear implant determines what signal will be sent to the brain for sound perception. Finally, test performance may be impacted by the child's speech, regardless of language modality used. It should be noted that the *presence* of an audiological device (i.e., cochlear implant or hearing aid) does not guarantee that the child has full access to spoken language.

In general, interpretation of all results should be approached with caution and understood within the context of the child, their language abilities and exposure, developmental history, and any modifications of the test (if applicable). Examiners must remain cognizant of the possibility that the presence of even a slight hearing difference, regardless of communication modality, may result in environmental conditions that impede incidental learning. For example, compared to a child with typical hearing, a deaf or hard of hearing child may have comparatively limited access to their environment, which reduces exposure and learning opportunities in their everyday life. This is especially relevant for children who were later identified as having a hearing difference. It is important to carefully consider one's history in an attempt to distinguish between performances related to cognitive functioning and those aspects of performance that reflect the environmental circumstances for the child.

Published literature on general outcomes for children with hearing differences has been highly variable, with the majority of the published research for children who utilize listening and spoken language focused on language outcomes. For children who utilize cochlear implants and hearing aids, variability of performance has been attributed to several factors. Children with cochlear implants have demonstrated varying degrees of speech comprehension and understanding (Dettman, Pinder, Briggs, Dowell, & Leigh, 2007; Geers, Tobey, Moog, & Brenner, 2008; Holt & Svirsky, 2008; Nicholas & Geers, 2007); and language outcomes are influenced by age of implantation, degree of residual hearing prior to implantation, maternal sensitivity, and socioeconomic status (Niparko et al., 2010; Quittner et al., 2013). For children with hearing aids, early identification, early intervention, and level of hearing difference are all significant factors to consider in terms of language and overall outcomes (Sininger, Grimes, & Christensen, 2010; Yoshinaga-Itano, Sedey, Coutler, & Mehl, 1998). For both groups, nonverbal cognitive abilities also appear to mediate language outcomes (Geers et al., 2008; Mayne, Yoshinaga-Itano, & Sedey, 2000). As noted, language development must be understood for each child, as it will highly influence the results of standardized testing, and examiners must make an effort to understand how the child's language impacts results on cognitive measures.

In terms of previously published literature on the cognitive profiles of children with hearing differences who utilize cochlear implants and hearing aids, variability has also been reported. While many of the published studies recognize the difficulty of generalization for this heterogeneous population, the trends in the literature report lower scores on measures of verbal abilities, including the Verbal Comprehension Index (VCI) (Geers & Moog, 1989; Geers & Sedey, 2011), and working memory tasks, including the Working Memory Index (WMI) (Burkholder & Pisoni, 2003; Geers & Sedey, 2011). It is believed that working memory is critical to the development of spoken language (Gupta & MacWhinney, 1997), and correlations have been found between working memory and language development in children with hearing differences (Hansson, Forsberg, Löfqvist, Mäki-Torkko, & Sahlén, 2004; Pisoni & Geers, 2000). While lower working memory skills have been primarily shown in children with cochlear implants (Pisoni & Cleary, 2003), some differences have been reported in children with hearing aids, and less profound levels of hearing sensitivity (Stiles, McGregor, & Bentler, 2011).

Given the large number of confounds and variability that can exist within this population, the current study aimed to limit the scope of the collected data to a more homogeneous population, controlling for some known factors that can lead to variability in outcomes. Children in the current study were all fit with assistive listening devices that allowed for access to sound, and have been regularly monitored, ensuring auditory access to spoken language. The sample collected is a sample of convenience, and all included children attended an independent school for children with hearing differences in the mid-Atlantic part of the United States at the time of testing. The school is an inclusive education program for children from birth to third grade that provides specialized services and support, including audiology and speech and language interventions. Classrooms are designed specifically to meet the needs of any child with a hearing difference, including classroom amplification, acoustic modifications, and smaller class sizes. While this study was intended to collect data on a specific subset of the general deaf and hard of hearing population, it should be noted that not all children have access to this level of support, and as a result, the trajectory of the child's language and cognitive development may differ. It is believed that the results of this study likely represent a "best case scenario" of what is possible for oral children with hearing differences in the context of appropriate access to their environment, supports, and early intervention.

A recent study of the WPPSI–IV with children who use listening and spoken English as a preferred communication modality and utilize hearing aids and/or cochlear implants (Costa, Day, & Raiford, 2016) revealed that the hearing difference sample performed lower on verbally-based subtests that required greater language output (i.e., Similarities, Vocabulary, and Comprehension) as compared to those with little to no expressive output. The differences seen in the Verbal Comprehension domain, however, were not as large as those seen in more heterogeneous samples. Significant differences were also seen on one Fluid Reasoning (i.e., Picture Concepts) and one Working Memory (i.e., Zoo Locations) subtest.

Based on the results of previous research, it was expected that the children in the current study would have significantly lower mean scores than a matched control group for the VCI and WMI.

Methods

Measure

The WISC–V is an individually administered, comprehensive clinical instrument for assessing the intelligence of children ages 6 years 0 months through 16 years 11 months (6:0–16:11). It provides primary index scores that represent intellectual functioning in specified cognitive areas (i.e., Verbal Comprehension Index [VCI], Visual Spatial Index [VSI], Fluid Reasoning Index [FRI], Working Memory Index [WMI], and Processing Speed Index [PSI]), a composite score that represents general intellectual ability (i.e., Full Scale IQ [FSIQ]), and ancillary index scores that represent the cognitive abilities in different groupings based on clinical needs (i.e., Verbal [Expanded Crystallized] Index [VECI], Expanded Fluid Index [EFI], Quantitative Reasoning Index [QRI], Auditory Working Memory Index [AWMI], Nonverbal Index [NVI], General Ability Index [GAI], and Cognitive Proficiency Index [CPI]). All of the WISC–V primary subtests from the final edition were administered for this special group study. The complementary index subtests that comprise the Naming Speed Index [NSI], Symbol Translation Index [STI], and the Storage and Retrieval Index [SRI] were not administered for the current study due to time constraints.

Participants

The sample consisted of children with hearing differences who attend an independent, inclusion-model school for children with hearing differences in the mid-Atlantic part of the United States. Participants were recruited as part of routine annual testing. This was a sample of convenience, and included children with hearing loss falling within at least the mild range unilaterally, and who use either a cochlear implant or hearing aid. None of the children had additional clinical diagnoses. The matched control samples were drawn from the pool of nonclinical children who participated in the standardization of the WISC–V. Pearson's Field Research staff recruited the standardization participants and compensated the children (i.e., their parents/guardians) for their participation. Participants for the matched control sample of nonclinical children were screened for general inclusion criteria used for the WISC–V normative sample listed in chapter 3 of the WISC–V Technical and Interpretive Manual.

Procedure

The data for children with hearing differences were collected between January 2015 and March 2016. For the sample, a team of three examiners[2] who are trained in both the standard administration of the WISC–V and working with children with hearing differences captured response information by writing the children's responses on the record forms and scoring all items.

The matched control sample was collected between April 2013 and March 2014, concurrent with the WISC–V standardization. For the matched control sample, examiners captured response information in the standard manner used for norming, which includes writing the complete verbatim response to each Verbal Comprehension subtest item and scoring all items. A team of several scorers at Pearson rescored all of the protocols. For each protocol, two independent scorers reevaluated all subjectively scored items using the final scoring rules, and an expert scorer or a member of the research team resolved any discrepancies between the two scorers as needed. All subtest raw scores were calculated by Pearson staff using the keyed item scores and the final scoring rules. The final subtest and composite norms were then applied.

Results

The demographic data for the group of children with hearing differences appear in Table 1.

For this study, education level was based on the number of years of school completed by the parent(s)/guardian(s). If the child resided with only one parent or guardian, the education level of that parent or guardian was assigned. If the child resided with both parents or with two guardians, the average of both individuals' education levels was used, with partial levels rounded up to the next highest level.

The demographic characteristics of the current sample disproportionately represent children with a parent education level of a bachelor's degree or more; all participants had a parent education level of at least some college. The group represents children who are Asian at a greater proportion than the population proportion and children who identify as Hispanic at a smaller proportion than the population proportion. The sample contains slightly more boys than girls. Within the WISC–V age range of 6–16, children who are 9–16 are not represented. All cases were drawn from the South region of the U.S.

The age of identification of hearing loss for the children ranged from birth to four years, five months of age, with unaided hearing levels in at least one ear ranging from mild to profound. The etiology of the hearing difference was unknown in 13 cases and hereditary in 2 cases. Four of the children used behind-the-ear (BTE) hearing aid devices, and 11 children used cochlear implant(s) (CI). When amplified, every child in the sample had at least partial access

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[2] The authors would like to extend special thanks to Colleen Caverly, M.A., Angela Tuner, M.A., and Meghan Pruett, M.A. for their assistance with data collection.

to speech sounds. Auditory access was measured utilizing Articulation Index Scores, which identified the percentage of speech sounds that can be detected when using devices. For the current sample, aided Articulation Index Scores ranged from 65 to 100 percent, in the better ear.

Table 1. Demographic Data for Children with Hearing Differences

N	15
Age	
Mean	7.2
SD	0.9
Range	6–8
Education[a]	
0–12 years of school, no diploma	—
High school diploma or equivalent	—
Some college or technical school, associate's degree	20.0
Bachelor's degree	80.0
Race/Ethnicity	
African American	13.3
Asian	20.0
Hispanic	6.7
Other	20.0
White	40.0
Region	
Midwest	—
Northeast	—
South	100.0
West	—
Sex	
Female	40.0
Male	60.0

Note. Except for sample size (*N*) and age, data are reported as percentages. Total percentage may not add up to 100 due to rounding.

[a] Education = parent education level.

Table 2 presents the mean subtest and composite scores for the children with hearing differences and matched control groups.

With the exception of the WMI and the AWMI, none of the mean composite score differences are significantly different between the hearing differences group and the matched control group. The WMI and AWMI differences show a large effect size, and the VECI shows a moderate effect size. The FRI, NVI, EFI, and CPI show small effect sizes. The effect size for the NVI is larger than that of the FSIQ. The VCI, VSI, PSI, FSIQ, QRI, and GAI effect sizes are negligible. The hearing differences group mean FSIQ and NVI are slightly higher than the population mean (i.e., 100).

At the subtest level, the hearing differences group mean on Comprehension, Picture Span, and Letter–Number Sequencing is significantly lower than in the matched control group. Large effects are present for the hearing differences group mean differences of two of the four subtests in the Verbal Comprehension domain. The lowest hearing differences group mean scores are present on Letter–Number Sequencing, Digit Span, Arithmetic, Information, and

Comprehension, and the highest occur on Similarities, Figure Weights, and Symbol Search. The hearing differences group mean scores on Similarities, Block Design, Figure Weights, Coding, and Symbol Search are higher than those of the matched control group. The largest effects occur on Letter–Number Sequencing, Comprehension, and Picture Span.

Table 2. Hearing Differences Compared to Matched Controls

Subtest/ Composite Score	Children With Hearing Differences		Matched Control					
	Mean	*SD*	Mean	*SD*	Difference	*t* value	*p* value	Standard Difference[a]
SI	11.9	2.1	11.0	2.0	-0.87	-1.09	NS	-0.42
VC	10.2	2.8	10.8	2.2	0.60	0.60	NS	0.24
IN	9.5	2.8	11.7	2.8	2.27	1.94	NS	0.81
CO	9.5	2.5	11.7	1.8	2.13	2.54	<.05	0.98
BD	10.9	2.5	10.4	2.5	-0.53	-0.55	NS	-0.21
VP	10.8	2.2	11.6	2.7	0.80	1.08	NS	0.32
MR	10.3	2.5	11.8	2.9	1.53	1.70	NS	0.57
FW	11.2	2.4	10.4	1.9	-0.80	-1.07	NS	-0.37
PC	10.1	2.9	11.2	3.0	1.13	1.02	NS	0.38
AR	9.1	2.2	10.3	3.4	1.13	0.92	NS	0.39
DS	8.9	3.0	10.9	2.7	2.00	2.07	NS	0.70
PS	9.6	2.5	11.9	2.5	2.27	2.19	<.05	0.91
LN	7.4	3.1	10.8	2.8	3.40	2.61	<.05	1.15
CD	10.4	3.6	10.0	1.8	-0.40	-0.37	NS	-0.14
SS	11.0	3.2	10.6	2.9	-0.40	-0.32	NS	-0.13
CA	9.8	3.7	10.3	3.1	0.53	0.42	NS	0.16
VCI	105.5	10.6	104.9	9.4	-0.67	-0.16	NS	-0.07
VSI	104.6	9.9	105.6	13.9	1.00	0.25	NS	0.08
FRI	104.3	12.7	106.5	9.9	2.27	0.68	NS	0.20
WMI	95.6	13.2	108.2	10.9	12.60	2.68	<.05	1.04
PSI	103.9	16.6	101.8	11.7	-2.13	-0.38	NS	-0.15
FSIQ	103.9	12.1	105.5	10.8	1.60	0.43	NS	0.14
VECI	101.5	11.5	107.5	8.6	5.93	1.43	NS	0.58
EFI	101.1	11.6	106.1	14.1	5.00	1.03	NS	0.39
QRI	100.9	9.8	101.9	14.1	0.93	0.20	NS	0.08
AWMI	90.0	15.4	104.9	13.6	14.87	2.57	<.05	1.02
NVI	103.9	11.9	107.4	10.9	3.47	0.87	NS	0.30
GAI	105.9	10.2	105.9	9.9	-0.07	-0.02	NS	-0.01
CPI	100.1	13.0	105.9	10.4	5.80	1.25	NS	0.49

[a] The Standard Difference is the difference of the two test means divided by the square root of the pooled variance, computed using Cohen's (1996) Formula 10.4.

WISC–V abbreviations are: SI = Similarities, VC = Vocabulary, IN = Information, CO = Comprehension, BD = Block Design, VP = Visual Puzzles, MR = Matrix Reasoning, FW = Figure Weights, PC = Picture Concepts, AR = Arithmetic, DS = Digit Span, PS = Picture Span, LN = Letter–Number Sequencing, CD = Coding, SS = Symbol Search, CA = Cancellation, VCI = Verbal Comprehension Index, VSI = Visual Spatial Index, FRI = Fluid Reasoning Index, WMI = Working Memory Index, PSI = Processing Speed Index, FSIQ = Full Scale IQ, VECI = Verbal (Expanded Crystallized) Index, EFI = Expanded Fluid Index, QRI = Quantitative Reasoning Index, AWMI = Auditory Working Memory Index, NVI = Nonverbal Index, GAI = General Ability Index, CPI = Cognitive Proficiency Index.

Discussion

This study provides data on the performance on cognitive testing of a specific group of children with hearing differences. The population sample consists of children who use listening and spoken language as a preferred communication modality, and who utilize hearing aids and/or cochlear implants to access spoken language. Unlike other studies on cognitive performance of heterogeneous groups of children with hearing differences, the present sample controlled for specific factors known to lead to variability in outcomes (i.e., primary communication mode, auditory access to language; and regular access to specialized educational, audiological, and speech and language services).

These results replicate previous research on cochlear implant users that demonstrated relatively lower scores on subtests from the Verbal Comprehension domain (Geers & Moog, 1989; Geers & Sedey, 2011). Large effects are present for the hearing differences group mean differences of two of the four subtests in the Verbal Comprehension domain. As noted previously (Day et al., 2015), for children who have access to sound via assistive technology and for whom spoken English is their primary language, opportunities for incidental learning and exposure to English may differ in important ways from children in the normative sample. Of the verbally-based subtests, the hearing differences sample performed lower on those that require higher exposure to incidental learning, and output that is more nuanced. These subtests also contain stimuli that require a higher level of language comprehension (e.g., Information and Comprehension). This trend of weaker performance on tasks that require sophistication of language skills and greater language output suggests that specific components of language continue to develop as language skills continue to strengthen.

When comparing with the analogous study of the WPPSI–IV with a similar population (Costa et al., 2016), both groups of children with hearing differences showed a relative weakness on the Comprehension subtest, performing significantly lower than the matched controls. While the WPPSI–IV study revealed significant differences on the Similarities and Vocabulary subtests, these differences were not found in the current sample. It is possible that because the children are older in the WISC–V sample and have received language-based intervention, they have made progress in some aspects of language. Interestingly, reviews of research on more heterogonous samples (e.g., various communication modalities, variable access to early intervention) found Verbal Comprehension scores that averaged one standard deviation below the mean of the normative sample (Krouse & Braden, 2011; Maller, 2003). While the differences in the Verbal Comprehension domain for this relatively homogeneous group are important, they are not as large as those seen with more heterogeneous samples.

Previous research has suggested that children with hearing differences demonstrate weaker performance on tests of working memory (e.g., Burkholder & Pisoni, 2003; Geers & Sedey, 2011). The mean composite scores for the WMI and the AWMI are significantly lower for the hearing differences group compared to the matched control group. These findings are consistent with previous research that demonstrates vulnerability in the area of working memory for children with hearing differences. When comparing these findings with the analogous study of the WPPSI–IV with a similar population (Costa et al., 2016), it is critical to note the differences between the Working Memory subtests on each measure. On the WPPSI–IV study, the children with hearing differences scored significantly lower on Zoo Locations, but not on Picture Memory, and the mean WMI score difference was not significant. For the current study, the children with hearing differences scored significantly lower on Picture Span and Letter–Number Sequencing, and the WMI and AWMI composite scores were significantly lower. The auditory nature of the WISC–V working memory tasks appears to introduce a clear disadvantage for children with hearing differences. Further, it is possible that tasks that require a higher level of cognitive load, or rely on verbal mediation, may present as more challenging for this population. Additional research is needed to determine the reason for performance variability within the Working Memory domain.

Among the index scores, there are a number of small and moderate effects that did not achieve statistical significance. This is not surprising; because the sample was a sample of convenience and relatively small, it would be impractical and would take many years to collect a sample large enough to demonstrate significance for these small and moderate effects. The *p* value merely answers one question: If there is no true difference (i.e., effect) in the population, how likely are the results found in this sample (or in those with more extreme results than these) due to chance sample fluctuation. The observed difference between the hearing differences group and the matched control group is not likely the result of happenstance due to the consistency of results across index scores as well as previous research with children with hearing differences.

It should be emphasized that the sample was one of convenience, and included children who utilize appropriate and consistently functioning technology and receive specialized educational and audiological services and supports. Further, the sample was limited to those children whose parents had an education level of at least some college. The limited demographic representation of this sample may limit the generalizability of results to the entire deaf and hard of hearing population, particularly to those who utilize different forms of communication, did not have early language access, and/or have additional co-morbid conditions. Instead, these results should be regarded as ideal outcomes; these findings shed promising light on what remains possible for those children who communicate orally when provided with optimal early educational and audiological support and early intervention.

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