Incidental Detection of Speech and Non-Speech by Children Using Cochlear Implants Compared to Children Using Traditional Amplification

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We compared the auditory detection skills of 11 children who use cochlear implants to 22 children with similar hearing loss who use hearing aids while engaged in a visual distraction task. The results were analyzed according to awareness of stimuli and latency of awareness to the stimuli. No statistically significant differences were found between participants with cochlear implants and those with hearing aids for any of the detection or latency variables, although clinically significant differences were seen between groups for detection of soft stimuli. Participants with better aided speech detection thresholds demonstrated significantly better detection of soft and loud speech and non-speech, regardless of device. As a group, participants who used cochlear implants had significantly better aided detection levels than those wearing hearing aids. Better aided detection thresholds resulted in better overhearing of speech and non-speech in quiet.

It is assumed that children with typical hearing acquire the phonologic, semantic, syntactic, and pragmatic aspects of language not only by hearing speech directed to them but also by overhearing speech directed to others. The mastery of grammar, for example, involves repeated exposure to morphological forms used in

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many different contexts and application of these rules to unique situations (Berko, 1958; Cazden, 1968). These grammatical forms are acquired in a similar order for all English speaking children (Brown, 1973; deVilliers & deVilliers, 1973) who progress through a stage of overgeneralization or over-application of these rules before they have acquired them fully.

Extensive data support the theory that language-learning occurs best and fastest for infants between the ages of 12 and 15 months in a mutually engaged social context where infant attention is maintained (Tamis-LeMonda, Bornstein, Baumwell, & Damast, 1996; Tamis-LeMonda, Bornstein, Kahana-Kalman, Baumwell, & Cyphers, 1998). However, research on vocabulary acquisition by slightly older children with typical hearing strongly supports the notion that, by the age of about 2 years, children can learn words through meaningful environmental exposure and understanding of adult intention, and that child-directed language and explicit teaching, while important, is not a requirement for word-learning (Tomasello & Barton, 1994). For instance, 24-month-olds in the Tomasello and Barton study inferred at least partial meanings of verbs based on an adult expression of success or failure ("whoops" or "there!") following use of these specific verbs while manipulating a toy. Beginning at a vocabulary size of about 200 words, children with typical hearing learning English exhibit a sharp increase in the size of their lexicon (Bloom, 2000) which is associated with the ability to ascertain meanings of unfamiliar words from their syntactic context (Evey & Merriman, 1998; Fenson et al., 1994; Graham, Baker, & Poulin-Dubois, 1998; Heibeck & Markman, 1987). This process is referred to as "novel mapping" and is distinct from "rapid word learning" in that, in novel mapping, the referent need not be paired explicitly with the object in order for the child to ascertain its meaning (Lederberg, Prezbindowski, & Spencer, 2000). Lederberg et al. suggest that rapid word learning precedes novel mapping and that the emergence of novel mapping is associated with vocabulary size rather than chronological age.

It has also been demonstrated that 2-year-olds with typical hearing are able to learn labels for novel objects through overhearing (Akhtar, 2005). In Akhtar's study, children performed equally well on novel word learning tasks when they were attending to adults in conversation as when the children were engaged in a distraction task. They learned words that were explicitly paired with a referent (i.e., "this is a modi") as well as those that were not (i.e., "put the modi over here"). This suggests that children with typical hearing, at least at around the age of 2 years, are able to learn words implicitly, from third-party interactions, and that directed language instruction is not a requirement in acquiring new words. Awareness of speech and the ability to isolate the acoustic segments of words are important prerequisites to early word-learning (see Hoff & Naigles, 2002, for a review). These auditory-based skills, in addition to working memory and verbal rehearsal (Houston, Carter, Pisoni, Kirk, & Ying, 2005), enable children to at least partially map meaning onto referents. Subsequent refinement of word meanings occurs through repeated exposure to words in a variety of contexts. This is referred to as the “data-providing view of input” (Naigles & Hoff-Ginsberg, 1998).

This is consistent with research demonstrating that the quantity and diversity of words children hear is directly related to vocabulary size (Hart & Risley, 1995; Schwartz & Terrell, 1983; Smith, 1999) and that hearing words in a variety of syntactic contexts aids in establishing meaning. In other words, children use “syntactic bootstrapping” when acquiring new words (Naigles & Hoff-Ginsberg, 1998). Hoff and Naigles (2002) found that the number and variety of words mothers used, and maternal Mean length of utterance (MLU) all positively predicted children’s vocabulary levels, with MLU accounting for the most variance in the dependent variables. Hoff and Naigles suggest that multiple exposures to a variety of words in complex contexts function as “multiple learning trials” and allow for “cross-situational learning” (p. 430).

Finally, researchers have shown that incidental exposure to language can also have an impact on speech production. Studies of second language acquisition demonstrate that adults exposed to Spanish through overhearing in childhood demonstrate better pronunciation of Spanish than adults who were never exposed as children (Au, Knightly, Jun, & Oh, 2002; Knightly, Jun, Oh, & Au, 2003).

Children with hearing loss are at a distinct disadvantage in this process whereby vocabulary is built and refined not only through attending to words in isolation, but through hearing words in a variety of syntactic contexts. Reduced auditory access to the acoustic cues of spoken language in the environment is thought to contribute to the difficulty experienced by children with hearing loss in acquiring vocabulary (Pittman, Lewis, Hoover, & Stelmachowicz, 2005; Stelmachowicz, Pittman, Hoover, & Lewis, 2004) and grammar (Moeller, Osberger, & Eccarius, 1986; Osberger, 1986). Having any degree of hearing loss reduces the number of times a specific word or grammatical form is heard as well as the acoustic clarity of that word or form, thereby slowing down the aforementioned process of rule application, overgeneralization, and acquisition.

There are substantial data on the auditory perceptual skill acquisition of children with hearing loss who use traditional amplification (hearing aids and/or FM systems) and cochlear implants (Carney et al., 1991; Eisenberg et al., 2006; Waltzman, 2006; Zwolan et al., 1997). Most studies use set-to-listen tasks consisting of words or sentences in varied listening environments in open-set or closed set formats. In documenting device effects, Boothroyd and Eran (1994) found that young children using cochlear implants functioned similarly on auditory perception tasks as children with 88 dB HL mean pure tone average (PTA) using appropriate acoustic amplification. Brackett and Peters (1996) found that implant users demonstrated open set phoneme perception on isophonemic word lists (Boothroyd & Nittrouer, 1988) in quiet and in noise similar to hearing aid users with severe hearing losses. Informal observation supports standardized test results; parents subjectively report that children with cochlear implants exhibit increased awareness to both environmental and speech sounds shortly after implantation (Cunningham, 1990; Osberger et al., 1991; Purdy, Farrington, Chard, & Hodgson, 2002; Thawin et al., 2006).

While these data highlight the exceptional listening skills of children with cochlear implants, none of these studies quantify the auditory alerting behaviors of children with cochlear implants in non-set-to-listen (i.e., more naturalistic) tasks. Interpolating from the acquisition process used by normally hearing children, which suggests that children learn language by hearing many examples in their environment, the assumption can be made that, if children with hearing loss can detect and alert to non-directed speech, they will possess at least the prerequisite skills for explicit and implicit language learning.

The purpose of this study is to determine if cochlear implant users detect non-directed familiar speech and environmental sounds more often, and faster than those who use hearing aids or FM systems. Based on research showing that children with profound hearing loss outperform their non-implanted peers on formal speech perception tasks, it was hypothesized that children using cochlear implants would demonstrate better and faster detection of environmental and speech stimuli than children with comparable hearing loss using acoustic amplification. This hypothesis was tested through observing and quantifying the sound detection behaviors of participants with hearing loss who were engaged in a quiet, visually distracting activity.

Participants. The participants were 11 cochlear implant users (mean age = 7.8

Table 1

Subject Data for Implant Users

	CA	**ID HL**	**Dur imp**	**PTA-R**	**PTA-L**	**Aided sp. det.**
CI-1	10-7	9 months	17 months	115	110	30
CI-2	6-3	22 months	31 months	105	100	30
CI-3	10-10	9 months	64 months	120	120	25
CI-4	4-1	17 months	7 months	105	NR	25
CI-5	7-11	8 months	3 months	98	95	28
CI-6	6-5	21 months	12 months	90	102	20
CI-7	9-3	20 months	3 months	90	115	25
CI-8	3-3	10 months	12 months	110	120	30
CI-9	8-11	14 months	52 months	NR	NR	25
CI-10	11-3	9 months	18 months	90	90	40
CI-11	5-11	20 months	18 months	117	105	23

Note. CA = Chronological age. ID HL = Age at identification of hearing loss. Dur imp = Duration of implant use. PTA-R = Pure average, right ear. PTA-L = Pure tone average, left ear. Aided sp. det. = Aided speech detection threshold. CI = Cochlear implant.

years). Ten of the cochlear implant users had a full insertion of the electrode array of the Nucleus 22 device, and 1 subject had a partial insertion with six electrodes active. Pre-implant, the mean three-frequency unaided PTA for the cochlear implant participants was 113 dB HL with a range of 90 to 120+ dB HL. Experience with the cochlear implant ranged from 3 months to 5-4 years with a mean of 1 year, 8 months. The mean aided SDT for the group was 27 dB HL (range 23 dB HL to 40 dB HL; see Table 1).

A group of 22 children with severe to profound hearing loss (mean unaided PTA of 97.3 with a range of 70 to 115 dB HL) was used for comparison (mean age = 8.5 years). All traditional amplification users had at least 2 years experience with their hearing aid or FM system. Their mean aided SDT was 35 dB HL (range 15 dB HL to 45 dB HL; see Table 2).

Stimuli. Two types of stimuli (speech and environmental) at two different levels (conversational and soft) were selected to assess the detection abilities of the

Table 2

Subject Data for Users of Hearing Aids

	CA	ID HL	Age ampl.	PTA-R	PTA-L	Aided sp. det.
HA-1	12-2	14 months	18 months	110	105	30
HA-2	6-3	17 months	18 months	95	101	30
HA-3	12-2	12 months	18 months	100	NR	30
HA-4	12-3	12 months	18 months	102	102	30
HA-5	6-9	1 month	13 months	78	82	30
HA-6	8-8	9 months	36 months	113	113	30
HA-7	4-4	18 months	24 months	86	86	15
HA-8	6-5	21 months	21 months	105	88	30
HA-9	8-0	18 months	18 months	88	88	25
HA-10	9-3	3 months	12 months	103	100	38
HA-11	10-7	14 months	16 months	105	98	40
HA-12	5-10	15 months	16 months	103	103	35
HA-13	5-7	4 months	4 months	103	108	35
HA-14	5-11	6 months	7 months	107	100	45
HA-15	5-2	22 months	22 months	120	106	45
HA-16	5-7	19 months	20 months	98	100	38
HA-17	10-8	34 months	48 months	115	117	40
HA-18	9-6	18 months	22 months	115	90	35
HA-19	22-11	13 months	22 months	98	90	35
HA-20	4-1	17 months	18 months	105	NR	35
HA-21	7-11	8 months	15 months	98	95	35
HA-22	6-5	21 months	21 months	90	102	58

Note. CA = Chronological age. ID HL = Age at identification of hearing loss. Age ampl. = Age at amplification. PTA-R = Pure tone average, right ear. PTA-L = Pure tone average, left ear. Aided sp. det. = Aided speech detection threshold. HA = Hearing aid.

participants. Speech stimuli of varying length (one vs. three syllables) were chosen for their semantic relevance, familiarity to young children, syllable pattern, and strong intonation contour/stress pattern. For example "hi" (one syllable, rising falling pattern, 0.6 s) and "it's my turn" (three syllables, stressed second syllable, falling intonation on third syllable, 1.0 s). Non-speech stimuli replicated common household (telephone) and environmental (siren) sounds that would be familiar and interesting to young children with limited auditory experience. These stimuli both were chosen for their sudden onset and acoustic pattern. The telephone consisted of a steady trill (0.5 s) and the siren was a rapidly rising upward tone (0.6 s). Environmental stimuli were generated electronically using the Musical Instrument Digital Interface (MIDI) Software and transferred to an audiocassette. Speech stimuli were spoken by a female speaker and recorded onto an audiocassette through a Sony TCM 5000EV, three-head cassette recorder which received a signal from a Shure remote microphone, clipped approximately 6 in. from the mouth of the speaker. Each of the speech and non-speech stimuli was equalized for overall root mean square (RMS) amplitude and then presented to listeners at 45 dB SPL to replicate the intensity of speech at a distance (or soft speech) and 75 dB SPL to replicate non-directed speech presented at a conversational distance. Each stimulus occurred five times in 6-s interval. Random intervals of silence ranging from 20 to 50 s in length were inserted between each stimulus in order to prevent the listener from anticipating the onset of the following stimuli.

Stimuli were presented to half of the listeners as follows:

"It's my turn"	45 dB SPL
Siren	75 dB SPL
"Hi"	75 dB SPL
Telephone ringing	45 dB SPL
"Hi"	45 dB SPL
Telephone ringing	75 dB SPL
"It's my turn"	75 dB SPL
Siren	45 dB SPL

To control as much as possible for habituation to the stimuli, a second tape with the stimuli occurring in reverse order was presented to the other half of the participants. Participants were randomly chosen to hear either Tape A or B through a coin toss at the beginning of the experimental session.

Procedure. Prior to the participant entering the room, a calibration tone on the tape was measured at 75 dB SPL at the participant's chair and approximate ear level using a Radio Shack sound level meter. Participants were seated at a table in a quiet room and visually engaged in a non-verbal task (painting a picture or completing a complex sticker puzzle). The experimenter instructed the participant to "Make this picture/puzzle. When you're finished, let me know." No mention was made of the fact that they would hear "sounds." The previously described stimuli were played via an audio tape player placed out of the participant's view. The experimental session was videotaped so that visual indicators of sound awareness and response time could be observed. Since the participants were taped routinely as part of their intervention sessions, this was not unusual for them.

Scoring. Three trained observers independently viewed each video tape and determined awareness of stimuli and latency of the response for each participant. Awareness was determined by observing three behaviors: gaze shift, startle, or verbal indication of detection (coded = presence/absence). Only these three behaviors were acceptable as indicators of sound awareness. Latency was measured by determining on which of the five occurrences in the 6-s interval, the behavioral cue for awareness occurred (coded = 1-6). There was 100% agreement among judges for awareness of stimuli. On 80% of the responses there was agreement among judges for response latency of awareness, which was well-above chance for this task (chance agreement being 16%). For the remaining 20% of the responses, judges were asked to view the videotape together in an effort to resolve discrepancies in establishing exactly when the participant was first aware of the stimuli. Consensus was reached for all responses.

Analysis. Independent samples *t*-tests were used to compare performance of implant users and hearing aid users on all dependent variables. Participants were then grouped based on participants' aided speech detection threshold. "Good detectors" had aided SDTs of equal to or less than 30 dB HL while "average/poor detectors" had aided SDTs of greater than 30 dB HL. The cut-off of 30 dB HL was selected as the group delineator since it represents the point at which roughly 65% of the acoustic cues for speech should be available to the listener, based on the articulation index (House, 1995), and is approximately in the middle of the speech banana as depicted on audiograms supplied to parents during pediatric testing. Awareness and latency as a function of type of stimulus (speech/non-speech) and intensity of stimulus (loud/soft) were also determined.

RESULTS

Device and speech detection threshold. Speech detection thresholds were related to amplification device. Cochlear implant users had significantly better aided SDTs than hearing aid users, $t(31) = 2.817$, $p = .008$. Ninety percent of the cochlear implant users had aided speech detection thresholds of equal to or better than 30 dB HL; only 41% of the traditional amplification users obtained equivalent aided benefit from their device. It should be noted that, as a group, the participants who used cochlear implants, while demonstrating significantly better aided speech detection thresholds, demonstrated significantly poorer unaided thresholds than children who used hearing aids, $t(31) = 3.918$, $p < .000$.

Device and detection/latency measures. No significant differences were ob-

Table 3

Device Effects on Awareness (Percentage Correct) and Latency (1-6) for Soft and Loud Stimuli

	Hearing aid users		Cochlear implant users	
	Detection	**Latency (*SD*)**	**Detection**	**Latency (*SD*)**
Soft – it's my turn	27%	5.32 (1.25)	45%	4.64 (1.75)
Soft – hi	45%	4.55 (1.79)	73%	3.64 (1.75)
Soft – telephone	23%	5.14 (1.78)	45%	4.36 (2.16)
Soft – siren	18%	5.68 (0.72)	36%	5.27 (1.56)
Loud – it's my turn	86%	2.50 (1.71)	91%	1.91 (1.22)
Loud – hi	82%	2.59 (1.97)	91%	2.27 (1.79)
Loud – telephone	91%	2.09 (1.63)	91%	1.82 (1.66)
Loud – siren	77%	2.91 (1.97)	82%	2.82 (2.09)

served between the implanted and the non-implanted group with respect to detection of loud stimuli, $t(31) = 0.132$, $p = .896$, or soft stimuli, $t(31) = 1.687$, $p = .102$. No significant between group differences were observed for latency of response to loud, $t(31) = 0 .643$, $p = .525$, or soft stimuli, $t(31) = 1.377$, $p = .178$. Tables 3 and 4 show that participants heard loud stimuli 71% of the time (range 0 to 100) between the 1st and 6th presentation (mean latency = 2.42). Participants detected soft stimuli 31% of the time (range 0 to 81) between the 2nd and 6th presentation (mean latency = 5).

Implanted children heard loud stimuli 71% of the time (range = 31 to 81%) between the 1st and 5th presentation (mean latency = 2.2). Hearing aid users detected loud stimuli 70% of the time (range = 0 to 100%) between the 1st and 6th presentation (mean = 2.5). Implanted participants heard soft stimuli 43% of the time (range 0 to 81%) between the 2nd and 6th presentation (mean latency = 4.6).

Table 4

Device Effects on Overall Latency (1-6) and Overall Awareness (Percentage Correct)

	Hearing aid users	**Implant users**
Overall latency	3.85	3.34
Latency to soft stimuli	5.17	4.47
Latency to soft speech	4.80	4.10
Latency to loud stimuli	2.52	2.20
Overall awareness	56%	69%
Awareness to soft stimuli	28%	50%
Awareness of soft speech	36%	59%
Awareness to loud stimuli	84%	89%

Hearing aid users heard soft stimuli 25% of the time (range = 0 to 81%) between the 3rd and 6th presentation (mean = 5.2).

While no statistically significant device differences were seen for awareness to the stimuli or response time, there was a trend for the participants who used cochlear implants to alert more often and more quickly to all stimuli. Effect sizes were calculated for detection of soft speech and detection of all soft stimuli, as differences between groups for these two dependent variables approached significance and were of clinical interest. Cohen (1988) describes effect sizes as *small* ($d = .2$), *medium* ($d = .5$), and *large* ($d = .8$). Medium effect sizes were found for detection of soft stimuli ($d = .602$), and detection of soft speech ($d = .543$) representing a moderate clinical difference between the implant group and hearing aid group on these two variables. Clinically significant differences were also observed between groups for latency to all soft stimuli ($d = .49$) and latency to soft speech ($d = .5$).

Speech detection threshold. When the participants were regrouped according to speech detection threshold (see Table 5), a different pattern emerged. Good detectors demonstrated statistically significantly higher detection rates and shorter latencies for soft stimuli when compared to poor detectors. Both groups responded similarly to loud stimuli. Those participants whose aided speech detection thresholds were equal to or lower than 30 dB HL alerted significantly more often to the soft stimuli, $t(30.8) = 2.848$, $p = .008$) than participants with aided SDTs of poorer than 30 dB HL. In addition, participants with better aided speech detection demonstrated significantly shorter latencies to the soft stimuli, $t(30.68) = 3.054$, $p = .005$, and specifically soft speech, $t(31) = 2.19$, $p = .036$, than participants with poor detection. Independent *t*-test analyses revealed no statistically significant differences between the detection groups with respect to

Table 5

SDT Effects on Awareness (Percentage Correct) and Latency (1-6) for Soft and Loud Stimuli

	SDT > 30 dB HL		SDT ≤ 30 dB HL	
	Detection	**Latency *(SD)***	**Detection**	**Latency *(SD)***
Soft – it's my turn	21%	5.43 (1.16)	42%	4.84 (1.62)
Soft – hi	36%	5.00 (1.57)	68%	3.68 (1.80)
Soft – telephone	7%	5.71 (1.07)	47%**	4.26 * (2.18)
Soft – siren	0%	6.00 (0.00)	42%**	5.21 * (1.32)
Loud – it's my turn	86%	2.71 (1.73)	89%	2.00 (1.41)
Loud – hi	79%	2.71 (1.73)	89%	2.32 (1.83)
Loud – telephone	86%	2.36 (2.02)	95%	1.74 (1.45)
Loud – siren	79%	2.86 (2.07)	79%	2.89 (1.97)

Note. SDT = Speech detection threshold.
* $p < .05$. ** $p < .01$.

Table 6

SDT Effects on Overall Latency (1-6) and Overall Awareness (Percentage Correct)

	SDT > 30 dB HL	SDT ≤ 30 dB HL
Overall latency	4.090	3.36*
Latency to soft stimuli	5.535	4.49**
Latency to soft speech	5.200	4.20*
Latency to loud stimuli	2.660	2.23
Overall awareness	49%	69%*
Awareness to soft stimuli	16%	50%**
Awareness of soft speech	28%	55%
Awareness to loud stimuli	82%	88%

Note. SDT = Speech detection threshold.
* $p < .05$. ** $p < .01$.

awareness of soft speech, $t(31) = 1.832$, $p = .077$. The good detectors alerted to "it's my turn" at 45 dB HL 42% of the time, whereas poor detectors alerted to this stimulus only 21% of the time. The good detectors alerted to "hi" at a soft presentation level 68% of the time; poor detectors alerted to the same stimulus 36% of the time. Medium effect sizes were seen for detection of soft speech ($d = .65$), however, suggesting a moderate clinical difference between good detectors and poor detectors for awareness of soft speech stimuli.

When the awareness and latency data were collapsed (see Table 6), it was found that participants with aided speech detection thresholds of better than 30 dB HL demonstrated significantly better overall awareness, $t(31) = 2.77$, $p = .009$, and shorter overall latencies, $t(31) = 2.27$, $p = .031$, compared to participants with poorer aided speech detection.

DISCUSSION

The purpose of this study was to compare the sound awareness behaviors of children using cochlear implants to those of children using hearing aids in a naturalistic environment. It was hypothesized that children using cochlear implants would demonstrate better and faster detection of non-directed speech and environmental stimuli than their peers with equivalent hearing levels using traditional amplification. Results of this study do not support this hypothesis. While the implanted children in this study *did* evidence superior performance on all detection tasks, none of these differences reached statistical significance.

When participants were classified according to their speech detection ability, statistically significant between-group differences emerged. Children with aided speech detection thresholds equal to or better than 30 dB HL demonstrated significantly better awareness of soft stimuli than children with poorer aided speech detection levels. The good detectors responded more quickly to soft stimuli as well. Good detectors did not show a statistical advantage over poor detectors with respect to awareness of soft speech, however, clinically significant differences were found between these two groups.

It is important to note that, even though there were no statistically significant *device* effects for detection or latency measures, participants with cochlear implants had significantly better aided SDTs than participants with hearing aids. All but one of the implant users were classified as good detectors while only 41% of the hearing aid users were categorized as such. In general, it can be expected that children with good aided access to speech using any device will alert more often and more quickly to soft stimuli in their environment than children with poor aided access to speech. Children with cochlear implants will be more likely to have good aided access to soft speech with their device.

It was interesting that, neither the implanted children, nor the good detectors demonstrated a statistical advantage on detection of soft speech. Only their awareness of soft *non-speech* was statistically superior. Again, moderate clinical differences were seen between amplification groups and speech detection groups for awareness of soft speech and latency of response to soft speech. The statistical similarity between groups might have been due to the relatively small sample size for this study. It is also possible that the soft speech stimuli were less acoustically interesting than the soft environmental stimuli or the loud stimuli, and therefore, none of the children responded as well to these stimuli. The environmental stimuli all had a sudden onset and a dramatic pattern, while the speech stimuli did not. A simple explanation for the lack of awareness to soft speech is that the soft speech stimuli were not as novel and were therefore not attended to as well as the environmental stimuli or the loud stimuli, especially while the children were engaged in a distracting task. The design of the study may have also contributed to this finding in that, participants' attention to soft stimuli might have waned more rapidly than attention to loud stimuli.

A final explanation is related to attention to multiple inputs over time. Although no subjects exhibited a decline in *overall* responsiveness from the beginning to the end of the experimental session, it is possible that participants were less able to divide their attention between auditory and visual inputs, particularly for less acoustically salient stimuli. Quittner, Smith, Osberger, Mitchell, and Katz (1994) and Smith, Quittner, Osberger, and Miyamoto (1998) showed that children who are deaf demonstrate poor visual attention and vigilance compared to their typically hearing peers, theoretically because they need to divide their visual attention between multiple tasks, since the auditory channel is impaired. Children with cochlear implants performed better on visual tasks in the Quittner et al. study, ostensibly because they could alert using their hearing, rather than through visual scanning of their environment. It is possible that children in this study, regardless of their aided SDTs, were less inclined to pay attention to softer, less novel stimuli when otherwise visually distracted, simply because attending to more than one sense at a time may pose specific challenges to a child with hearing loss. Including typically hearing peers as a control group for this study may have shed additional light on this result.

Results of this study have implications for aural habilitation practices and spoken language acquisition of children with hearing loss. For example, at the very least, children who have better access to soft stimuli are more likely to attend to speech in their environment that is not prefaced by their name. The child with good access to soft speech will be exposed to more words and language forms more often during the course of a day, replicating to some degree the experience of children with normal hearing. By contrast, children with poor access to soft sounds will be less likely to pick up on the rich spoken language in their environment through overhearing. They will only alert to speech presented from within a normal conversational distance and at sufficient intensity. Speech at a distance and speech in noise will be practically inaccessible.

For those children who have very poor speech detection, even louder than conversational level speech will not be accessible without an attention-getter. This was clear when some of the traditionally amplified participants did not even alert to loud (75 dB SPL) speech and non-speech stimuli.

As clinicians, we can provide important prerequisite tools for language learning by first optimizing the child's amplification. Speech detection levels of better than 30 dB HL provide very good access to environmental speech and non-speech stimuli presented at average (conversational) and soft levels. A traditionally amplified child with a severe to profound hearing loss may be considered a candidate for a cochlear implant if speech detection levels such as these cannot be attained using acoustic amplification. As well, if a child who uses a cochlear implant demonstrates poor speech detection using his/her device, a modification of that child's MAP may be necessary. A child with good speech detection levels but poor auditory attention will require therapy to help him/her become a better user of the incoming acoustic signal. It may be that the child does not attend to speech not prefaced by his/her name because he/she does not know it is important to attend to speech in the environment. Some practice listening to non-directed speech will be necessary. For example, the clinician or parent can address the child during aural habilitation sessions without prompting the child to "listen."

CONCLUSIONS

Using a cochlear implant clinically appears to improve speech detection in quiet, even during a minimally distracting activity. This is found to be true even for children with very poor unaided thresholds (115-120+ dB HL). Cochlear implant users perform similarly to traditionally amplified individuals who have good speech detection thresholds regardless of unaided thresholds, particularly with respect to detection (vs. latency of detection) of stimuli. This would make sense, as speech detection provides information as to what a person is capable of hearing with their amplification. This does not, however, provide information as to how a listener utilizes this information. For example, a child may detect the word *cat* but may not be able to identify or comprehend the word. Research on the implicit vocabulary and language learning of children who are deaf using cochlear implants and/or hearing aids is needed. This study demonstrates that implanted children, who may not have had any access to conversational level speech pre-implant, demonstrate sound awareness skills equivalent to well-amplified children using hearing aids. When compared to peers with similar unaided thresholds, cochlear implant users have the opportunity to obtain significantly better aided speech detection thresholds, therefore maximizing their ability to detect and benefit from speech and language in their environment.

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